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# A Comprehensive Review of Farm Bill Contributions to Wildlife Conservation

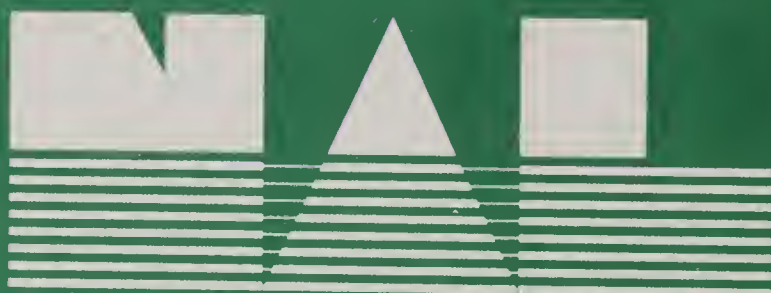
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Wildlife Habitat Management Institute

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# A Comprehensive Review of Farm Bill Contributions to Wildlife Conservation, 1985–2000

## Technical Report

USDA/NRCS/WHMI-2000

December 2000

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## Abstract

A comprehensive review of the scientific literature was undertaken to determine wildlife responses to programs established under the conservation title of the 1985 Food Security Act as amended in 1990 and 1996 (Farm Bill). Literature was annotated and summaries of wildlife responses were provided for the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Wildlife Habitat Incentives Program (WHIP) and Environmental Quality Incentives Program (EQIP). The report recognized that Farm Bill conservation programs were created to serve many purposes. Foremost among these purposes was to enable America's farmers and ranchers to be better stewards of their lands. In general, wildlife responded positively to improvements in land stewardship, particularly when the needs of wildlife were considered in conservation planning and implementation. Whereas authors acknowledged that their understanding of wildlife responses to Farm Bill conservation programs was still incomplete, they concluded that these programs were making significant contributions toward conservation of the nation's fish and wildlife resources.

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# A Comprehensive Review of Farm Bill Contributions to Wildlife Conservation, 1985–2000

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# Executive Summary

The future of wildlife in this country is inseparably tied to activities taking place on private lands. Agriculture is by far the dominant user of these lands with about 50% of the United States or 900 million acres managed as cropland, pastureland, or rangeland. Decisions made by America's farmers and ranchers, therefore, directly affect the land's plant life, soil, water, and wildlife. Government agricultural programs and policy have had a large influence on the choices available to farmers and ranchers in the management of their lands.

Changes in the occurrences of native plants and animals are a reflection of our stewardship of the land. Loss of biodiversity and declines in wildlife populations during the past century suggest that the country has fallen short on its stewardship responsibilities. Landcover changes associated with shifts in federal agricultural policy and programs, and farmers' land-use practices have had important consequences for wildlife in landscapes dominated by agriculture. In the Great Plains, for example, dramatic declines in grassland-dependent wildlife since the 1950s have been attributed to federal agricultural policy and programs that favored conversion of native habitats to agricultural purposes.

A myriad of agricultural, environmental, social, political, and economic considerations led to the passage of the 1985 Food Security Act (hereafter, Farm Bill). Inclusion of the conservation title in the 1985 Farm Bill marked a turning point in private land conservation. Amendments to the 1985 Farm Bill in 1990 and 1996 sought to further enhance wildlife benefits of conservation programs. Improvements in legislation that were sought by wildlife conservation interests included the (1) creation of state technical committees, (2) establishment of an application review procedure that ranked applications based on their environmental benefits (e.g., proximity to wildlife habitat, diversity of seed mixture, use of native plants), and (3) recognition of coequal status of wildlife with soil and water conservation. Additionally, new programs, such as the Wetlands Reserve Program (WRP), Wildlife Habitat Incentives Program (WHIP), and Environmental Quality Incentives Program (EQIP) were created that offered great hope for improving wildlife habitat on private land. To further improve these landmark programs so that they might realize their full potential, a better understanding of wildlife responses to Farm Bill conservation programs was urgently needed.

The purpose of this document was to tell us what these programs have done for wildlife conservation. This review began as an attempt to identify and annotate all published literature on Farm Bill conservation programs (Appendix I and II). Hundreds of scientific articles were assembled, and it soon

became apparent that in addition to identifying and annotating the literature, there was need to synthesize information to focus attention on the most important results. To assist with this task, leading scientists from universities and research or management organizations outside the agency were invited to contribute chapters summarizing major research findings in their area of expertise. Participants in this effort are recognized by the conservation community not only for their outstanding research contributions, but also for their demonstrated commitment to communicating their important results to land managers and nontechnical audiences.

Our understanding of Farm Bill contributions to wildlife conservation, though still largely incomplete, is best for the Conservation Reserve Program (CRP), the oldest and largest (size and cost) of the Farm Bill conservation programs. Because birds are considered important indicators of ecosystem function and because the wildlife community has given highest priority to conservation of grassland birds, our understanding is primarily based on assessments of bird responses to CRP in the Midwest and Plains states. Additionally, bird population objectives for some species (e.g., waterfowl) generally are clearly defined and habitat associations are well understood compared to other wildlife groups, so it is possible to measure program contributions to conservation goals.

Information on wildlife responses to other Farm Bill programs is greatly limited. Consequently, to provide a better understanding of WRP's contributions to wildlife conservation, we summarized all of the published literature pertaining to biological changes in restored wetlands. Treatments of WHIP and EQIP, however, were limited to descriptions of the programs and identification of information needs. The following highlights were taken from program sections.

### **Conservation Reserve Program (CRP)**

The ways in which CRP is implemented, and, therefore, its potential effects on wildlife, vary geographically. For example, in contrast to the Midwest and Great Plains regions where CRP fields have been planted almost exclusively in grasses, 62% of the 2.7 million acres of CRP in the Southeast were enrolled in tree planting practices, primarily loblolly pine. The replacement of agricultural lands with tree plantings in a forest-dominated landscape (48% of landbase) favors forest wildlife but may result in a long-term net loss of habitat for nonforest wildlife. During the first one to three years following planting, pine plantations are characterized by low-growing grasses and other nonwoody plants, and they provide habitat for grassland and regionally declining, early successional bird species. As the stand matures, nonwoody plants are replaced by shrubs and developing pines. Bird diversity increases with stand age as shrubland birds colonize the stand. The number of bird

species declines as pines mature and canopy shading eliminates herbaceous ground cover. In these older pine stands, thinning and prescribed burning may enhance habitat quality for bird species preferring grassland and shrublands. Because of the extended growing season and high growth rates in the Southeast, grasslands in the region need to be disturbed every three to five years to prevent encroachment by trees and shrubs and maintain their attractiveness for nonforest wildlife. (Note that less frequent disturbance is recommended in the northern Great Plains.) Overall, the potential wildlife benefits of CRP in the Southeast are substantial, but they may be limited by the selection of specific practices (e.g., pine plantations) and vegetative covers (e.g., fescue).

Midwestern and Plains states have been the primary beneficiaries of CRP. Changes in land use associated with strong landowner interest in CRP have had an important influence on grassland-dependent wildlife in these regions. Responses to CRP vary not only by species but also by region, year, field characteristics (e.g., age, size, configuration, vegetation, disturbances), and features of surrounding habitats. Strong evidence was presented that bird abundance in CRP habitats in the Midwest was substantially higher than in rowcrop fields typically replaced by CRP plantings. Additionally, reported nest abundance in midwestern CRP habitat was 10-times greater than that in rowcrop fields. Nest success for birds breeding in CRP was approximately equal to or higher than that measured in alternative agricultural or grassland habitats. Limited evidence indicates that reproductive success and survival of birds in CRP habitats in the Midwest were sufficiently high to yield positive population growth for a few species (including several of high conservation concern). To date, however, a significant positive relationship between the establishment of CRP habitat and population growth has been documented for only two grassland bird species in the Midwest. Overall, the evidence accumulated to date indicates that CRP habitat in the Midwest and Great Plains likely contributes to the population stability or growth of many, but not all, grassland bird species.

The effects of CRP on waterfowl have been thoroughly documented in the northern Great Plains. The region is the principal breeding area for upland nesting ducks, including mallard, gadwall, blue-winged teal, northern shoveler, and northern pintail. Extensive conversion of grasslands to cropland reduced the amount of perennial upland cover that ducks needed for successful nesting; consequently, waterfowl production in the region was declining before CRP. A review of published and unpublished studies clearly indicated that CRP cover was highly attractive to nesting hens and that nest success in CRP cover was higher than other common cover types. Overall, nest success in CRP fields exceeded that level considered necessary for population maintenance of the above five duck species. Waterfowl nest success in other upland

nesting habitats also improved after implementation of CRP, suggesting that wildlife benefits extended beyond program areas to the entire prairie-wetland landscape. Between 1992 and 1997, it was estimated that CRP in the Prairie Pothole Region contributed to a 30% improvement in duck production or 10.5 million additional ducks. Assuming no further conversion of grasslands to cropland, maintenance of at least five million acres of CRP will be required to sustain a positive population growth rate for waterfowl in the Prairie Pothole Region. Minor adjustments in targeting would provide additional benefits to wetland-associated wildlife.

### **Continuous Enrollment Conservation Reserve Program**

Wildlife responses to conservation buffers, such as those being implemented through the Continuous Enrollment Conservation Reserve Program, were assessed based on a review of studies of bird communities in various strip-cover habitats such as grassed waterways, roadsides, fencerows, contour buffers, and terraces. Bird abundances and nest densities are higher in strip-cover than in block-cover habitats; however, nest success in strip-cover habitats is often very low. Use of habitats by birds depends upon their vegetation structure (height and density) and species composition (herbaceous vs. woody, grass vs. forb, native vs. introduced). Some bird species are limited by the width of strip-cover habitats; thus, there is a positive relationship between bird species richness and strip-cover width. Contributing to this may be the aversion that some bird species have for habitat edges. Vegetation management practices (e.g., mowing and grazing) influence bird communities both directly and indirectly. The amount of grassland surrounding herbaceous strips influences the occurrence and nesting success of birds in the strip cover. Rates of nest predation and brood parasitism by brown-headed cowbirds increase near wooded edges. Because some strip-cover habitats may function as ecological traps, there is an urgent need to identify and evaluate bird source and sink subpopulations in agricultural landscapes. Land-use decisions may vary depending upon wildlife management objectives, thus planning and evaluation of buffers will require a clear statement of conservation goals.

### **Wetlands Reserve Program (WRP)**

The Wetlands Reserve Program (WRP) provides incentives for landowners to restore function and value to degraded wetlands in agricultural landscapes on a long-term or permanent basis. Since authorization of the program in the 1990 Farm Bill, landowner interest has resulted in substantial enrollment. As of June 2000, over 912,000 acres were enrolled in WRP: 696,461 acres of permanent easements (76%); 161,201 acres of 30-year easements (18%); and 54,818 acres of 10-year cost-share agreements (6%). An additional 500,000 acres of unfunded projects have been offered for enrollment into the program. Approximately 55% of the lands currently enrolled consist of former bottom-land hardwood wetlands and riparian floodplain habitats. Approximately 15%


of the area consists of emergent wetland and open water complexes, and 30% is nonwetland buffer areas. Although current WRP enrollments have resulted in establishment of diverse wetland habitats, few quantitative data have been published depicting actual wildlife benefits of wetlands restored under the program. Therefore, studies on a variety of nonWRP wetland restoration projects were used to make inferences on the wildlife benefits derived from wetlands restored under WRP. The published literature on wildlife response to wetland restoration supports the premise that WRP is making a substantial contribution to the habitat needs of wetland wildlife throughout the country, particularly in areas where significant enrollments are occurring (e.g., Lower Mississippi Alluvial Valley and California's Central Valley).

### **Wildlife Habitat Incentives Program (WHIP)**

The Wildlife Habitat Incentives Program (WHIP) is one of a suite of conservation provisions added to the amended 1985 Food Security Act in 1996. WHIP was developed to assist landowners with habitat restoration and management activities specifically targeting fish and wildlife, including threatened and endangered species. Within the framework of state, regional, and national habitat priorities, WHIP funds were allocated to states based on plans developed by state conservationists in consultation with their state technical committees. Special consideration was given to locally led initiatives with substantial outside funding and partnership participation. Of the \$50 million available for WHIP in 1998 or 1999, \$30 million was distributed to states for financial and technical assistance in 1998 and \$20 million in 1999. This distribution resulted in 4,600 projects affecting 672,000 acres in 1998 and 3,855 projects on 721,249 acres in 1999. WHIP projects averaged 146 (1998) or 187 (1999) acres in size and \$4,600 in cost-share. WHIP targeted a wide range of fish and wildlife species, from economically and culturally important species such as northern bobwhite and Atlantic salmon (*Salmo salar*) to threatened and endangered species such as Karner blue butterfly (*Lycaeides melissa samuelis*) and Indiana bat (*Myotis sodalis*). WHIP also provided cost-share for restoration of critical aquatic habitat such as cold water streams and rare terrestrial habitats in oak savanna, longleaf pine, prairie, and riparian ecosystems. WHIP was extremely popular with landowners and conservation partners because it targeted wildlife and addressed important management needs identified at the local level that were not eligible for cost-share under other USDA conservation programs.

### **Environmental Quality Incentives Program (EQIP)**

Most EQIP practices have the potential to provide some benefits to fish and wildlife resources if they are planned with these resources in mind. The stated program purposes are to provide technical and financial assistance to farmers and ranchers that face the most serious threats to soil, water, and related natural resources, including grazing land, wetlands, and wildlife habitat. Practices with the primary purpose of addressing threats to soil and water and



grazing lands can be planned to also address habitat needs of important fish and wildlife resources identified by local work groups. In this manner, EQIP can be used as a powerful fish and wildlife habitat enhancement tool while addressing a broad range of natural resource concerns in agricultural landscapes.

### **Highly Erodible Land and Swampbuster**

U.S. Department of Agriculture (USDA) programs since 1985 have included conservation provisions that require an environmental standard to be achieved on certain categories of land in order to remain eligible for other USDA farm program benefits. The highly erodible lands and wetlands conservation provisions collectively work to reduce the rate of soil erosion from highly erodible croplands and to reduce the rate of conversion of other highly erodible lands and wetlands to crop production. These provisions do not create wildlife habitat directly, but collectively support the conservation gains made by CRP and WRP. While the greatest effect of these provisions is the reduction of soil erosion and the associated delivery of sediments and other pollutants to aquatic systems, substantial habitat gains made by other programs would not occur without the linkage of these compliance provisions with USDA financial assistance. For example, it was estimated that without wetland protection, the average breeding duck population in the Prairie Pothole Region eventually could decline by over 30% or 2.8 million breeding ducks/year. Consequences of noncompliance with highly erodible lands and wetlands conservation provisions for other wildlife groups and regions are unknown.

### **Conclusion**

Farm Bill conservation programs were created to serve many purposes. Foremost among these purposes was to enable America's farmers and ranchers to be better stewards of their lands. In general, wildlife have responded positively to these improvements, particularly when their needs were considered in conservation planning and implementation. Whereas our understanding of wildlife responses to Farm Bill conservation programs is still incomplete, there is no question that these programs are making significant contributions toward conservation of the nation's fish and wildlife resources.

# Foreword

Settlement of the continent by Europeans beginning in the eighteenth century produced many changes in North American land forms and vegetation (hereafter, landcover). Unquestionably, agriculture was the major contributor to landcover changes. Suitability of land for agriculture greatly influenced settlement patterns in North America (Maizel et al. 1998). As expansion rapidly proceeded westward during the 1800s and early 1900s, farms were created at the population frontier; areas too wet or too dry were leapfrogged to be farmed later when drainage or irrigation was possible. Other areas with poor climate, steep slopes, or soils unsuitable to support cropland, pastureland, or hayland uses were either farmed unsuccessfully or never farmed at all.

Nowhere is the influence of agriculture on landcover more evident than in the fertile midsection of the nation, the Great Plains. Once the continent's largest ecosystem, the vast grasslands, shrublands, and savannas that characterized the region, historically supported a tremendous abundance and diversity of plants and animals (Dinsmore 1994). However, conversion of grasslands to agricultural purposes has been extensive, exceeding 99 percent in some states (e.g., Iowa and Minnesota; Noss et al. 1995). Associated with landcover changes in the Great Plains has been a concomitant change in the communities of birds and other animals that rely on grassland habitats. For example, dramatic declines in grassland bird species since the 1950s are attributed to changes in the agricultural landscape of the region (Gerard 1995). Extensive loss and degradation of grasslands in the Great Plains resulted in its designation as one of the nation's most endangered ecosystems (Noss et al. 1995).

The large influence that agriculture has on wildlife and their habitats presents us with both a challenge and an opportunity. As stated in the current NRCS strategic plan (USDA 1997):

*“Agriculture has had a substantial impact on the distribution and abundance of fish and wildlife populations. But as agriculture has been a significant factor in many wildlife declines, it also can be a major factor in restoring wildlife populations. Soil and water conservation has been and will continue to be the foundation of NRCS assistance to landowners and communities. Achieving the targets for soil and water resources, grazing land, and wetlands will produce parallel improvements in fish and wildlife habitats as well.”*

Clearly, with nearly 70% of the conterminous United States held in private ownership and 50% managed as cropland, pastureland, or rangeland, successful partnerships between landowners and conservation interests are critically important to achievement of wildlife goals.



Greater prairie chicken (W. Hohman)

***The large influence that agriculture has on wildlife and their habitats presents us with both a challenge and an opportunity.***

A myriad of agricultural, environmental, social, political, and economic considerations led to the passage of the 1985 Food Security Act (hereafter, Farm Bill) that included for the first time a chapter devoted to conservation (Berg 1994). Amendments to the 1985 Farm Bill in 1990 and 1996 retained and expanded conservation provisions such that there are now about 20 agricultural conservation programs with a combined funding level of \$2.5 billion/year. Most of these programs have significant potential for affecting fish and wildlife and their habitats (McKenzie 1997).

*The Conservation Title of the 1985  
Farm Bill as amended in 1996  
elevated the importance of wildlife  
in the delivery of conservation programs  
to the nation's privately owned lands.*

The Conservation Title of the 1985 Farm Bill as amended in 1996 elevated the importance of wildlife in the delivery of conservation programs to the nation's privately owned lands. Recognizing the opportunities and challenges related to conserving and enhancing fish and wildlife habitat, the Under Secretary of Agriculture for Natural Resources and Environment and the Chief of the NRCS convened a wildlife scoping team to consider the agency's problems and needs associated with delivering planning assistance to land-owners and communities. The wildlife scoping team was broad-based, involving NRCS staff and representatives from our partners with wildlife and agricultural interests.

The resulting reports, *Framework for the Future of Wildlife* and *Barriers to Providing Wildlife Assistance*, identified problems, established goals, and offered recommendations for achieving goals (USDA 1996a, b). One of the team's recommendations was the establishment of a technology institute as part of the NRCS National Science and Technology Consortium to interact with academic institutions, partner agencies, nongovernment organizations, and other institutes within the Consortium to develop new ideas and concepts related to aquatic and terrestrial habitat management. In response to this need, NRCS established the Wildlife Habitat Management Institute in 1997 to work with conservation partners to develop and disseminate scientifically based technical materials that will assist NRCS field staffs and others to promote conservation stewardship of fish and wildlife and deliver sound habitat management principles and practices to America's land users.

To better understand how Farm Bill conservation programs were affecting wildlife, I asked my staff in January 2000 to identify and review all published literature on wildlife responses to Farm Bill programs. Hundreds of scientific articles were assembled and it soon became apparent that in addition to identifying and annotating the literature, there was need to synthesize information to focus attention on the most important results. To assist us with this task, I invited leading scientists from universities and research or management organizations outside the agency to contribute chapters summarizing major research findings in their area of expertise. Participants in this effort are recognized by the conservation community not only for their outstanding

research contributions, but also for their demonstrated commitment to communicating their important results to land managers and nontechnical audiences. The resulting report is a current and comprehensive document that reflects the best judgment of the scientific community as to the effects of Farm Bill programs on wildlife.

## Acknowledgments

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# Introduction

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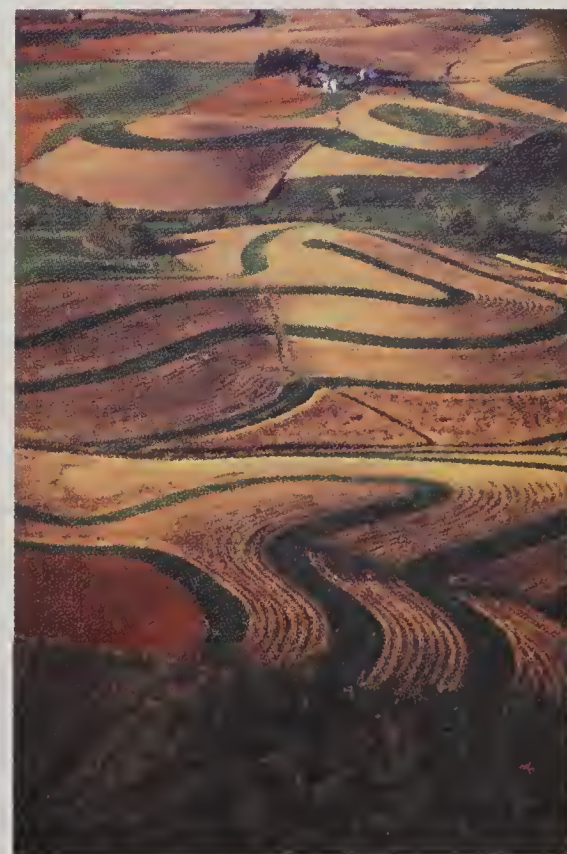
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The future of wildlife in this country is inseparably tied to activities taking place on private lands. Agriculture is by far the dominant user of these lands with about 50% of the United States or 900 million acres managed as private cropland, pastureland, or rangeland. Decisions made by America's farmers and ranchers directly affect the land's plant life, soil, water, and wildlife. Decisions affecting stewardship of these resources cannot be understood apart from landowners' most basic need, the ability to support themselves and their families. Making a living from the land has never been easy—not at the time of settlement and not today, in spite of the many technological advances that were made during the previous century. U.S. agricultural programs and policies have had a large influence on the choices available to farmers and ranchers in the management of their land.

Changes in the occurrences of native plants and animals are a reflection of our stewardship of the land. Loss of biodiversity and declines in wildlife populations during the past century suggest that we have fallen short on our stewardship responsibilities. Landcover changes associated with shifts in federal agricultural policy and programs, and farmers' land-use practices have important consequences for wildlife in landscapes dominated by agriculture. In the Great Plains, for example, dramatic declines in grassland-dependent wildlife since the 1950s have been attributed to federal agricultural policy and programs that favored conversion of native habitats to agricultural purposes. Indeed, according to Dahlberg (1992), the legacy for agricultural goals, institutions, and policies in the twentieth century was a dramatic reduction in the abundance and diversity of native plants and animals.

I have a more optimistic view about the future of wildlife in agricultural landscapes. Today, we recognize that stewardship of private lands is a shared responsibility between public and private interests and that expenditure of public funds for private land conservation is one of our government's wisest investments, yielding multiple benefits. New partnerships being forged between agricultural and conservation interests are based on mutual respect, improved understanding of the many challenges faced by those land users seeking to make their livelihoods from the land, greater awareness about how

*The future of wildlife in this country is inseparably tied to activities taking place on private lands.*



Iowa landscape (D. Eilers)

*... the conservation title  
in the 1985 Food Security Act ...  
was a turning point in our approach  
to conservation of private lands.*



Iowa CRP (L. Betts)

agricultural activities relate to conservation goals, and acceptance of shared stewardship responsibilities. I believe that inclusion of the conservation title in the 1985 Food Security Act (hereafter, Farm Bill) was a turning point in our approach to conservation of private lands.

A myriad of agricultural, environmental, social, political, and economic considerations led to the passage of the 1985 Farm Bill. Included in the 16-page Conservation Title of the 1985 Farm Bill were the Highly Erodible Land and Wetlands Conservation Compliance Programs, as well as the Conservation Reserve Program (CRP). The highly erodible lands and wetlands conservation provisions collectively work to reduce the rate of soil erosion from highly erodible croplands and to reduce the rate of conversion of other highly erodible lands and wetlands to crop production. These provisions generally do not create wildlife habitat directly, but collectively support the conservation gains made by the CRP and other Farm Bill programs. Some habitat enhancement may occur on highly erodible croplands if land users choose to implement conservation systems with holistic goals. While the greatest effect of these provisions is the reduction of soil erosion and the associated delivery of sediments and other pollutants to aquatic systems, there are substantial habitat gains made by other programs that would not occur without the interaction of these compliance provisions with the other USDA programs.

The Conservation Reserve Program provides compensation to farmers who cease production of agricultural commodities on erodible and other environmentally sensitive lands and establish perennial grass or trees on enrolled lands. Whereas CRP was originally conceived as a dual-purpose commodity supply control and soil erosion reduction program, it has evolved into a multipurpose conservation program with wildlife conservation now recognized as one of its core purposes (McKenzie 1997). CRP enrollment currently stands at 31.4 million acres, five million acres below the 36.4 million-acre cap established in 1996. Approximately 80% of CRP acres are planted with grass cover, 6% trees, 14% wildlife habitat, and 3% buffers. CRP participation is highest in Plains and midwestern states: Texas (3.9 million acres), Montana (3.2 million acres), North Dakota (3.2 million acres), Kansas (2.5 million acres), Iowa (1.6 million acres), Minnesota (1.5 million acres), Missouri (1.4 million acres), and South Dakota (1.3 million acres).

CRP was not the first land retirement program implemented by USDA to protect soils, reduce crop surpluses, control overproduction, and support commodity prices. Predecessors of CRP included the Agricultural Adjustment Act of 1933, Agriculture Conservation Program (1936), Soil Bank Act (1956), Wheat Production Program (1962), and Feed Grain Program (1972). Important shortcomings of these programs for wildlife were the short duration of contracts, late planting date, undiversified planting mixtures, frequent distur-

bance, and lack of technical assistance. For example, acreage reduction under Soil Bank and Feed Grain Programs was accomplished by using one-year contracts that required participants to plant cover (generally seed grain) after 15 June and mow, disk, or plow cover before grain maturity in mid to late July. Annual land retirement programs implemented between 1961 and 1983 resulted in increased soil erosion and contributed to declines in some grassland-dependent wildlife (Berner 1984). CRP requirements for 10-year contracts, diverse seeding mixtures that included forbs, elimination of disturbances except under emergency conditions, and provision of technical assistance to program participants were major advancements for wildlife in the 1985 Farm Bill.

Amendments to the 1985 Farm Bill in 1990 and 1996 sought to enhance wildlife benefits of CRP. Improvements in legislation that were sought by wildlife conservation interests were creation of state technical committees, establishment of application review procedure that ranked applications based on their environmental benefits (e.g., proximity to wildlife habitat, diversity of seeding, use of native plant species), and recognition of coequal status of wildlife with soil and water conservation. Additionally, new programs, such as the Wetlands Reserve Program (WRP), Wildlife Habitat Incentives Program (WHIP), and Environmental Quality Incentives Program (EQIP) were created that offered great potential for improving wildlife habitat on private land. Further improvements in Farm Bill programs require a better understanding of wildlife responses to existing programs.

The purpose of this document is to tell us what these programs are doing for wildlife conservation. As indicated in the Foreword, this review began as an attempt to identify and annotate all published literature on Farm Bill programs. The document has evolved into a comprehensive collection of program summaries contributed by leading experts in the field. As you will learn, our understanding of Farm Bill contributions to wildlife conservation, though still incomplete, is best for the CRP, the oldest and largest (size and cost) of the Farm Bill programs. Because birds are considered important indicators of ecosystem function and because the wildlife community has given highest priority to conservation of grassland birds in the Great Plains region, our understanding is largely based on assessments of bird responses to CRP conducted in the Midwest and Plains states. Additionally, bird population objectives generally are clearly defined and habitat associations are well understood compared to other wildlife groups, so it is possible to measure program contributions to conservation goals.

Information on wildlife responses to other Farm Bill programs is greatly limited. Consequently, to provide a better understanding of WRP's contributions to wildlife conservation we summarized all of the published literature pertaining to biological changes in restored wetlands. Treatments of WHIP

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Black-necked stilts (W. Hohman)

and EQIP, however, were limited to descriptions of the programs and identification of information needs.

Wildlife are indicators of the health of the environment. As such, they are good measures of the success of our conservation programs. Our hope is that this document will contribute to a better understanding of the environmental benefits that we have gained through Farm Bill programs and opportunities for further improvements in these important and worthwhile programs.

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# Highly Erodible Land and Swampbuster Provisions

## Conservation Compliance and Wetlands Conservation Provisions of the Omnibus Farm Acts of 1985, 1990, and 1996

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Iowa landscape (Tim McCabe)

### Abstract

*USDA programs since 1985 have included conservation provisions that require an environmental standard to be achieved on certain categories of land in order to remain eligible for other USDA farm program benefits. The highly erodible lands and wetlands conservation provisions collectively work to reduce the rate of soil erosion from highly erodible croplands and to reduce the rate of conversion of other highly erodible lands and wetlands to crop production. These provisions generally do not create wildlife habitat directly but collectively support the conservation gains made by the Conservation Reserve and the Wetlands Reserve Programs. Some habitat enhancement may occur on highly erodible croplands if land users choose to implement conservation systems with holistic goals. While the greatest effect of these provisions is the reduction of soil erosion and the associated delivery of sediments and other pollutants to aquatic systems, there are substantial habitat gains made by other programs that would not occur without the interaction of these compliance provisions with the other USDA programs.*

### Introduction

For over 50 years, United States Department of Agriculture (USDA) conservation programs had primarily focused on reducing high levels of soil erosion and providing water of adequate quality and quantity to support agricultural production. Technical and financial assistance programs were offered to agricultural producers on a voluntary basis. USDA also offered commodity adjustment, disaster, and insurance programs to producers of agricultural commodities that were motivated exclusively by economic factors. The Food Security Act of 1985 brought significant change in the way the federal government addressed agricultural conservation issues. While participation in

*... Food Security Act of 1985 ...  
conservation provisions:  
Highly Erodible Land,  
Wetland Conservation, and the  
Conservation Reserve Program ...  
collectively set an environmental  
standard for agricultural  
crop production.*

USDA programs has always been voluntary, the changes brought about by the 1985 Food Security Act linked some conservation standards to all USDA farm program benefits. Since about 85% of agricultural producers participated in USDA farm programs, these changes were significant. This section briefly describes the legislative provisions that brought about those changes and what the impacts of those changes were to wildlife habitat. The report by Zinn (2000) provides an excellent description of this legislation for those desiring more information.

Prior to 1985, the emphasis of USDA conservation programs had been on providing technical and financial assistance for the voluntary application of soil and water conservation practices. The Food Security Act of 1985 created three substantial new conservation provisions: Highly Erodible Land (HEL), Wetlands Conservation, and the Conservation Reserve Program (CRP). The HEL provisions included Conservation Compliance and Sodbuster. The Wetlands Conservation Provision was nicknamed "Swampbuster." The HEL and Swampbuster provisions represented a new approach by halting access to federal farm program benefits to producers who did not meet conservation program requirements (Zinn 2000). The CRP took highly eroding cropland out of production in return for 10-year rental payments. All three provisions have been retained in amended form in subsequent farm bills passed in 1990 and 1996. These provisions collectively set an environmental standard for agricultural crop production.

## Highly Erodible Land

Highly erodible land (HEL) is defined by USDA as land that has a soil erodibility index (EI)  $\geq 8$ . The EI is defined by factors from the Universal Soil Loss Equation (USLE, Wischmeier and Smith 1978) or Wind Erosion Equation (WEQ, USDA Soil Conservation Service 1978), whichever is applicable. The EI is computed using the soil, climate, and topographic variables from the USLE and WEQ in the numerator and the T-value (i.e., the tolerable limit required to maintain productivity) in the denominator. The EI calculated using this procedure does not include the effect of management practices such as contour farming or conservation tillage; therefore, it represents an index of potential erosion based upon natural conditions. Program rules generally define fields as HEL if more than a third of the area of the field consists of soil map unit components that are HEL.

Conservation Compliance applies to HEL that produced an agricultural commodity anytime during the period 1981-1985. Agricultural producers who cultivate HEL must have fully implemented an approved conservation plan by 1995. Producers who are out of compliance risk losing eligibility for most farm support programs on all the land they farm. The 1996 amendments (FAIR Act of 1996) expanded producer flexibility, allowed producers to self-certify compliance with their conservation plan when applying for benefits,

and removed crop insurance from the list of program benefits that can be denied. Of the 382 million acres of cropland in the United States in 1992, only about 28% of it qualifies as HEL (USDA-NRCS 1994), hence the Conservation Compliance Provision does not apply to over 70% of U.S. cropland.

Sodbuster applies to HEL that is newly converted to agricultural production from permanent cover such as pasture, rangeland, or forest. It requires producers who convert HEL to agricultural production to follow an approved conservation plan or they will lose eligibility for most farm support programs. Sodbuster discourages the conversion of HEL to cropland by requiring application of conservation practices, thus avoiding the undesirable effects of cropping HEL (increased erosion and sedimentation; reduced water quality; reduced wildlife diversity, abundance, and habitat). An additional benefit of sodbuster comes through supporting the conservation gains of CRP and Conservation Compliance by discouraging additional conversions of HEL. However, sodbuster provisions do not prevent conversion of permanent cover types to cropland. HEL can be converted to cropland when an approved conservation plan is applied, thus preserving the landowner's eligibility for farm program benefits. There are about 399 million acres of rangeland, 395 million acres of forestland, and 126 million acres of pastureland in the United States. Of those totals, about 41% of the rangeland, 32% of the forestland, and 46% of the pastureland occur on soils that meet the definition of HEL (USDA-NRCS 1994). The nonHEL portions of those landcover types are not subject to the sodbuster provisions, so conversion to cropland (and access to USDA farm program benefits) is not limited by HEL requirements.

Conservation plans approved by local Soil and Water Conservation Districts are required under the HEL provisions. Those plans, prepared with the assistance of the Natural Resources Conservation Service (NRCS), result from an evaluation of soil and site conditions, landowner objectives, and soil and water conservation treatment needs. The farm operator agrees to manage the HEL fields according to the plan. Conservation plans include management and practice specifications to reduce soil erosion. Examples of such practices include contour farming, terraces, conservation tillage (often including minimum amounts of crop residue left on the surface after planting), grassed waterways, cropping system specifications (i.e., crop rotation), and other practices. In some cases these practices also may benefit wildlife by providing food and/or cover suitable for some species, while in other cases there may be no benefits to wildlife. Converting a permanent cover type (i.e., pasture, rangeland, forest, etc.) to cropland would rarely result in an improvement in wildlife habitat. While the HEL provisions do not address wildlife habitat, there may be qualitative habitat improvements in agricultural ecosystems from the application of some conservation practices.

*An additional benefit of sodbuster comes through supporting the conservation gains of CRP and Conservation Compliance by discouraging additional conversions of highly erodible land.*

Because of political pressure in 1986 and 1987, the NRCS (formerly, Soil Conservation Service) allowed the use of Alternative Conservation Systems or scaled-down versions of conservation plans that would “substantially reduce” soil erosion rates without imposing an undue hardship on the producer. Concern was then expressed (Robinson 1988) that the teeth had been removed from the compliance mechanism.

### **Changes to the HEL Provisions Brought by the 1996 Farm Act**

Conservation Compliance and Sodbuster have both been retained in subsequent Farm Acts since 1985. However, they have been amended in response to concerns of the agricultural community that the provisions had been enforced too vigorously and inconsistently from county to county (Zinn 2000). Consequently, the 1996 FAIR Act included the following modifications to the HEL provisions: (1) violators have up to a year to meet compliance requirements; (2) expedited variances have been developed for weather, pest, or disease problems; (3) approved third parties are allowed to measure crop residue (per conservation tillage requirements) and that those measurements include the top two inches of soil; (4) producers are allowed to modify conservation plans while maintaining the same level of treatment; and (5) local county committees may permit relief if a conservation system causes a producer undue economic hardship (Zinn 2000).



WRP restoration in Iowa (L. Betts)

### **Wetlands Conservation Provision**

Swampbuster, or the Wetlands Conservation Provision, withdraws USDA farm program benefits from producers who convert wetlands after 1985 for the production of agricultural commodities. This incentive helped to protect wetlands from conversion. During the early settlement period of America, wetlands were perceived as an impediment to economic development, and up until the mid-1970s, wetland drainage and conversion was an accepted land-use policy (Mitsch and Gosselink 1986). Conversion of wetlands to cropland production accounted for 87% of the wetland losses during the period 1954-1974 (Frayer et al. 1983). From the mid-1970s to the mid-1980s, the role of agricultural development in wetland conversions had diminished to 54% (Dahl and Johnson 1991). By 1985, concern for wetland habitats had become so widespread that this provision was included in the omnibus Farm Act. More recent studies reveal that the annual rate of wetland loss has continued to decline and that agriculture's role in wetland loss during the 1982-1992 period had declined to about 20% (Flather et al. 1999). While Swampbuster's main impact has been to reduce agriculturally induced wetland conversions, it also has contributed to bids for the CRP and eventually for the Wetlands Reserve Program (WRP).

Swampbuster protects existing wetlands from conversion to crop production. It does not create or restore wetlands or require management on them. The

*While Swampbuster's main impact has been to reduce agriculturally induced wetland conversions, it also has contributed to bids for the CRP and eventually for the Wetlands Reserve Program.*

following is an example of the positive effect that Swampbuster made: Many wetlands are characterized by great variability in the hydrologic cycle exhibiting years of very wet conditions, and others periods of very dry. Austin (1998) reported that widespread drought during 1988-1993 reduced wetland habitat available to waterfowl, causing a marked reduction in waterfowl production and noted that some species also declined due to the intensification of agricultural activities. The dramatic recovery of most duck species since 1994 resulted primarily from heavy precipitation beginning in 1993, which replenished many wetlands and flooded thousands of acres of land that had recently been used as cropland. During the dry phase of this cycle, it could have been easier to install drainage systems (i.e., ditches and tile lines) in these fields, but Swampbuster's effect was to inhibit drainage of these fields for fear of losing USDA farm program benefits. When the wetter phase of the cycle returned in 1993 and continued for at least seven years, the result was extensive areas of wetlands on land that had recently been in agricultural production. Swampbuster preserved this habitat that may have otherwise been lost.

**Land-use Changes**

Increased soil erosion and sediment deposition have been associated with the increases in cropland in the post-war era, but particularly since the rapid expansion of cropland that occurred during the 1970s. Concomitant to the implementation of the Conservation Provisions of the recent Farm Acts (1985, 1990, and 1996) have been shifts in the kind of land used for crop production. These changes are the net result of increased awareness on the part of agricultural producers, successful delivery of technical assistance, and the conservation provisions of the recent Farm Acts. Because of the confounding effect of these independent forces, it is not possible to single out specific cause and effect relationships, but it is evident that the “carrot and stick” approach to farm program benefits of the recent Farm Acts got the immediate attention of the agricultural community, particularly those producing commodity crops on HEL.

Evidence of the positive effect of linking land stewardship with farm program benefits can be observed from reviewing results from the National Resources Inventory (NRI) (USDA-NRCS 1994) and as reported by Flather et al. (1999). In 1982, 73% of the cultivated cropland was experiencing sheet and rill erosion rates lower than the T-value. By 1992, that level had increased to nearly 79% of the cultivated cropland (USDA-NRCS 1994). Likewise, wind erosion rates on cultivated cropland in the Plains states and other areas subject to wind erosion have declined. The proportion of cultivated cropland protected from wind erosion increased from 79 to 84% from 1982 to 1992 (USDA-NRCS 1997). These improvements stem from improved technology applied on the land and the conservation provisions of USDA Farm Acts since

*Evidence of the positive effect of linking land stewardship with farm program benefits can be observed from reviewing results from the National Resources Inventory . . .*

1985, including the removal of 34 million acres of eroding cropland that was enrolled in the CRP.

Other indicators of soil erosion that suggest better land stewardship are shown in Table 1. Sheet and rill erosion, as estimated from the USLE, declined nationally on both cultivated and noncultivated cropland from 1982 to 1992. In addition, wind erosion as estimated by the WEQ, declined in all regions except the Pacific Coast. Erosion rates declined between 1982 and 1992 primarily because much of the cropland area with elevated erosion rates was enrolled in the CRP, removing it from cultivation and protecting it with perennial vegetation for 10- to 15-year contracts, beginning in 1986. Another indication of better stewardship was the area of cropland with lower values of the erodibility index (EI) between 1982 and 1992. The number of acres in each of the EI categories for cropland have been reduced since 1982 (Table 1). Erodibility index values greater than or equal to 8 are considered to be highly erodible and those acres declined by 16%. Again, this is the result of land-use shifts where the most erodible cropland acreage has been shifted to other uses, indicating that USDA programs since 1985 targeted those lands with the greatest potential for environmental damage.

*National Resources Inventory data for 1982 and 1992 . . . indicate that sheet and rill erosion rates on cultivated cropland dropped from 4.5 to 3.5 tons/acres/year and wind erosion rates dropped from 3.7 to 2.9 tons/acres/year.*

National Resources Inventory data for 1982 and 1992 (USDA-NRCS 1994) indicate that sheet and rill erosion rates on cultivated cropland dropped from 4.5 to 3.5 tons/acres/year and wind erosion rates dropped from 3.7 to 2.9 tons/acres/year. Much of the erosion reduction came as a result of the CRP removing 34.4 million acres of eroding cropland from cultivation by 1992, but Conservation Compliance and Sodbuster were strong motivators to take action. Acres of cultivated cropland dropped from 366,199,800 acres to 325,462,100 acres.

Thompson et al. (1989) reported that even a relatively modest mandatory restriction on soil loss resulted in major reductions in erosion rates with modest increases in total production costs. While some doubts about the effectiveness of the HEL provisions had been expressed because Alternative Conservation Systems were permitted (Robinson 1988), it is clear from the preceding discussion that these provisions did make a difference. Research by the Economic Research Service also verifies this point; in the absence of compliance mechanisms, between 5.8 to 13.2 million acres (of HEL and wetlands) would be economically profitable to convert to crop production, depending on assumptions about future prices (Heimlich et al. 1998).

National Resources Inventory data also suggest that both the rate of wetland conversion to agriculture and the relative proportion of agriculture's contribution to wetland conversion declined from 1982 to 1992 (USDA-NRCS 1994, Brady and Flather 1994). Until this decade, wetland losses due to agricultural

activity had been the leading cause of wetland conversion, but these data reveal that the relative proportion of loss due to agriculture had declined to 20%. The average annual loss rate due to agriculture during this decade (31,000 acres/year) was about 20% of the average annual rate estimated by the Fish and Wildlife Service (Dahl and Johnson 1991) for the period 1974-1983. Wetlands in the Prairie Pothole Region are particularly vulnerable to agriculture drainage because most basins (80%) are less than one acre in size and greater than 75% are typically flooded only seasonally or temporarily during the growing season (Cowardin et al. 1995). While programs operated by the U.S. Fish and Wildlife Service to conserve wetlands and provide nesting habitat for waterfowl are very important, Reynolds and Loesch (in preparation) reported that without some form of wetland protection program, such as the Swampbuster provision, drainage of small, shallow wetlands would likely resume at previous high rates. They projected that without wetland protection the average breeding duck population in the Prairie Pothole Region eventually could decline by over 30% or 2.8 million breeding ducks/year.

The HEL and Swampbuster provisions were successful because they offered both the “carrot and stick”—penalties for noncompliance and rewards for compliance. Neither of these had the force of law, land users could still opt out if they were willing to forgo all USDA farm program benefits. Successes claimed by advocates of the CRP and WRP must acknowledge the role that the Highly Erodible Lands and Wetlands Conservation Provisions of the Food Security Act of 1985 played in motivating land users to apply for enrollment into the CRP and WRP. Land-use changes for the last few years have yet to be documented, but there is indication of increased conversion of marginal lands to cropland to compensate for a depressed agricultural economy, in part financed by USDA programs.

## Wildlife Response

The HEL provisions did not directly create habitat for wildlife, but their impact was manifest indirectly (Robinson 1988, Brady 1988). They reduced soil erosion rates from highly erodible croplands or discouraged the conversion of HEL to crop production, thus protecting riparian, wetland, and aquatic habitats from excessive delivery of sediments and related pollutants. Additionally, these programs forced producers to evaluate how they wanted to use their agricultural lands. The alternative from the expense and inconvenience of complying with the Conservation Compliance provisions and risk of losing USDA benefits by violating those provisions was to bid their HEL land into the Conservation Reserve Program. Without this substantial incentive, the CRP would not have been nearly so successful.



Feeding northern pintail (W. Hohman)

*... without wetland protection the average breeding duck population in the Prairie Pothole Region eventually could decline by over 30% or 2.8 million breeding ducks/year.*

Robinson (1988) reported the main contribution of Conservation Compliance to wildlife improvement would probably come in the area of water quality, leading to better habitat for fish and other aquatic animals. Brady (1988) made a similar statement regarding Sodbuster. Robinson (1988) went on to state that it is likely that Compliance itself would have a relatively small impact on terrestrial wildlife species compared with CRP and Swampbuster, since much of the cropland subject to compliance would continue to be used for crop or hay production.

About 83% of compliance plans utilize crop residues or conservation tillage to help control erosion (Zinn 1998). Some have documented that benefits to wildlife increase as soil conservation practices are applied to croplands (e.g., Miranowski and Bender 1982). Others have suggested that this is not always the case, but that if wildlife habitat is jointly considered with other cropland management objectives, there can be benefits to wildlife habitat (Brady 1985, Brady and Hamilton 1988, Warner and Brady 1994). The net effect of conservation systems that include such practices as conservation tillage, contour strip-cropping, grassed backslope terraces, and field border strips may be beneficial to wildlife habitat if some (unspecified) level of biotic integrity is retained in the landscape mosaic (Warner et al. 1984, Warner and Brady 1994, Brady 1985). For example, the practice of leaving crop residues on the surface after planting (i.e., conservation tillage) has been shown to be beneficial for some species (Warburton and Klimstra 1984, Castrale 1985, Basore et al. 1986, Rodgers and Wooley 1983, Wooley et al. 1985, Best 1985, Duebbert and Kantrud 1987). There are only about 10 species of songbirds that regularly nest in cropfields and they generally have exhibited stable population trends (Best et al. 1997), although concern has been expressed that conservation tillage may act as an ecological trap for some (Best 1985). Warner and Havera (1989), and Warner et al. (1989) documented substantial use of waste grain by some wildlife during the dormant season.

The dramatic recovery of waterfowl populations in the Prairie Pothole Region since 1993 and population increases of Le Conte's sparrow have coincided with the amelioration of drought conditions in the Prairie Pothole Region (Austin 1998, Igl and Johnson 1999). To a great extent, this is the synergistic result of Swampbuster's effect of conserving wetlands, high CRP enrollments in the region, and favorable weather conditions.

## Conclusion

*The HEL and Swampbuster provisions of recent Farm Acts generally do not create additional wildlife habitat but help maintain or reduce the rate of loss of existing habitat . . .*

The HEL and Swampbuster provisions of recent Farm Acts generally do not create additional wildlife habitat but help maintain or reduce the rate of loss of existing habitat, including much of that developed by the CRP and WRP. The HEL provisions reduce erosion from HEL croplands and reduce the rate of conversion of HEL lands to crop production, thus helping to reduce

delivery of sediments and related pollutants to receiving waters. This impact will benefit fish and other aquatic organisms directly, while terrestrial wildlife will be impacted indirectly. Better stewardship of HEL croplands may provide habitat benefits to wildlife if management decisions are broader than just erosion control. These provisions provide strong motivation for land users to enroll their HEL cropland into the CRP or wetlands into the WRP and discourage them from converting other HEL lands or wetlands to crop production; thus, they collectively support the conservation gains made by the other provisions. The net effect of the interaction of all these Farm Act provisions results in substantial wildlife habitat improvements under existing patterns of land use that otherwise would not be possible if the various provisions were implemented independently.

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**Table 1. Comparison of cropland erosion indicators from 1982 to 1992 (USDA Natural Resources Conservation Service 1994).**

Indicator	1982	1992	Units
Soil erosion <sup>1</sup>	4.0	3.1	Tons/acre/year
Soil erosion <sup>2</sup>	3.4	2.4	Tons/acre/year
El <sup>3</sup> < 2	81,400	78,645	Acres × 1000
2 ≤ El < 5	134,023	125,738	Acres × 1000
5 ≤ El < 8	80,281	72,328	Acres × 1000
El ≥ 8 (HEL <sup>4</sup> )	124,847	105,238	Acres × 1000

<sup>1</sup>Soil erosion determined by the Universal Soil Loss Equation (Wischmeier and Smith 1978).

<sup>2</sup>Soil erosion determined by the Wind Erosion Equation (USDA SCS 1978).

<sup>3</sup>Erodibility Index (El) is an index of erosion potential determined from the erosion equations.

<sup>4</sup>Highly Erodible Land (HEL) is defined as soil map unit components with an El ≥ 8.



# Conservation Reserve Program (CRP)

## Grassland Bird Use of Conservation Reserve Program Fields in the Great Plains

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### Abstract

*The area enrolled in the Conservation Reserve Program in the Great Plains is enormous: nearly 18 million acres, or more than 7 million hectares, in Montana, North Dakota, South Dakota, Wyoming, Nebraska, Colorado, Kansas, Oklahoma, and Texas. This change in land use has had a huge influence on grassland bird populations. Many, but certainly not all, grassland species flourish in CRP habitats. Responses to the program vary not only by species, but by region, year, vegetation composition in a field, and whether or not a field was hayed or grazed. Further, the large scale of CRP has allowed researchers to begin to address other important conservation questions, such as the effect of the size of habitat patch and the influences of landscape features. Although the CRP provisions of farm bills have been beneficial to grassland birds, it is critical that gains in grassland habitat induced by the program not be offset by losses due to sodbusting.*

### Grasslands Are Imperiled, Considered the Nation's Most Threatened Ecosystem

Grasslands have been termed the nation's most threatened ecosystem (Samson and Knopf 1994, Noss et al. 1995). The absolute areal losses of grassland have been extensive. Losses of native grassland totaled 99.9 percent for tallgrass prairie in many states and 70-80 percent for mixed-grass prairie. Remaining grasslands and the wildlife that depend on them also have suffered from fragmentation (the division of grassland into smaller patches, surrounded by inhospitable habitats), as well as invasion and planting of woody vegetation (Johnson 1996).

Fortunately, in the Great Plains of the United States, the majority of land enrolled in the Conservation Reserve Program has been planted to grasses, often mixed with legumes. The result has been an enormous conversion of



Western meadowlark (K. Hollingsworth)



cropland in the landscape to perennial grassland (Johnson et al. 1993). This change has helped mitigate the loss of natural grasslands to some extent, at least insofar as CRP provides habitat for grassland birds.

## **Major Declines in Grassland Bird Populations Are Associated with Grassland Losses**

*Associated with the conversion of prairie to cropland on a large scale has been a concomitant change in the communities of birds and other animals that rely on grassland habitats.*

Associated with the conversion of prairie to cropland on a large scale has been a concomitant change in the communities of birds and other animals that rely on grassland habitats. Historical accounts tell of rich abundances of prairie wildlife that now can only be imagined (e.g., Dinsmore 1994). Widespread and systematic surveys of most bird species did not begin until the mid-1960s, with the advent of the North American Breeding Bird Survey (Robbins et al. 1986). (The Breeding Bird Survey, an annual survey conducted in spring since 1966, enlists volunteer birders who count birds according to prescribed methods at designated locations throughout the United States and southern Canada.) Thus, extensive quantitative evidence of changes in grassland bird populations exists for only the past 30 or so years, well after most grassland losses occurred. Nonetheless, the Breeding Bird Survey indicates that many grassland birds have fared poorly, even during that period. In fact, no other avian habitat group or guild has as many declining populations (Peterjohn and Sauer 1999).

## **Croplands and Haylands Are Unsuitable for Most Grassland Birds**

The cropland that largely replaced prairie is avoided by many bird species, which cannot find the necessary habitat structure in cultivated fields. Most birds that do nest in cropland suffer reproductive failure because of frequent agricultural operations (Rodenhouse and Best 1983). Likewise, hayfields often are used by grassland birds, but mowing operations can be very detrimental to the birds and their nests (Bollinger et al. 1990, Frawley and Best 1991). Both cultivated fields and hayfields are likely to be population “sinks” (*sensu* Pulliam 1988), in that reproduction in those areas is not sufficient to offset mortality and thereby to maintain populations.

## **Many Remaining Grassland Habitats Are of Reduced Quality**

Remaining grasslands tend to occur as small patches scattered about the landscape (fragmented), mere remnants of the vast expanses of prairie extant before European settlement. Birds are vulnerable to fragmentation effects, above and beyond habitat loss. Fragmentation reduces the size of habitat patches, increases exposure of birds to often-deleterious edge effects, and isolates habitat patches from one another. These influences are discussed later in somewhat more detail.

Further, settlement of the northern Great Plains by Europeans also brought major increases in woody vegetation. Ever-present winds induced settlers to plant tree claims to protect farmsteads and shelterbelts to reduce soil erosion in fields. Also, inadvertent increases of woody vegetation resulted from fire suppression (McNicholl 1988).

Grasslands invaded by woody vegetation typically contain *more* bird species than those without (Arnold and Higgins 1986). Importantly, however, these species tend to be edge or generalist species, which use a variety of habitats; among these species are brown thrasher, gray catbird, song sparrow, American robin, and common grackle. Such species have plentiful habitat elsewhere, and their populations are robust. Concomitantly, the addition of trees may reduce the quality of habitat for true grassland species, such as Sprague's pipit and Baird's sparrow. These prairie species have much more restricted habitats and breeding ranges and require maintenance of open grasslands for their survival.

Woody vegetation can influence grassland birds in several ways. First, it reduces the total area of grassland and fragments it. Second, it precludes certain species from using grassland areas that remain (Whitmore 1981, Kahl et al. 1985). Third, trees and shrubs provide perches for raptors, other avian predators, and cowbirds and travel lanes for mammalian predators. Fourth, species attracted to the woody vegetation may forage in adjacent grasslands and compete with prairie species.

### **CRP Provides Suitable Habitat for Many Species**

Because of the plentiful winds and highly erodible soils, the Great Plains has been a priority area for the Conservation Reserve Program. As of September 1999, the enrollment in CRP in Montana, North Dakota, South Dakota, Wyoming, Nebraska, Colorado, Kansas, Oklahoma, and Texas totaled nearly 18 million acres (more than 7 million hectares). The majority of those lands were planted to introduced or native grasses, the former typically mixed with legumes. Grasslands established under the program offer the potential to mitigate some of the detrimental effects that have occurred to native grassland. Several studies have found CRP fields to be highly attractive to breeding grassland birds. The species that most commonly breed in CRP fields vary geographically, however.

One evaluation of bird use of CRP habitats has been conducted annually since 1990 on several hundred fields in four northern Great Plains states (Johnson and Schwartz 1993a, b; Johnson and Igl 1995). In the early years of that study, Johnson and Schwartz (1993a) found grasshopper sparrows to be fairly common in all nine counties in which they surveyed (Table 1). In contrast, lark buntings, western meadowlarks, and horned larks were com-

*Grasslands invaded by woody vegetation typically contain more bird species than those without . . . however, these species tend to be edge or generalist species, which use a variety of habitats . . .*

mon or abundant in the western counties but rare or absent in the eastern counties. The opposite trend was evident for savannah sparrows, clay-colored sparrows, bobolinks, common yellowthroats, and sedge wrens.

Hanowski (1995) presented information on breeding birds of 30 CRP fields in western Minnesota during 1993 (Table 2). The species composition in those fields was generally similar to that presented by Johnson and Schwartz (1993a).

Delisle and Savidge (1997) studied the breeding-bird use of 10 CRP fields in southeastern Nebraska. Their most common species were dickcissel and grasshopper sparrow (Table 3). Densities they reported are not strictly comparable to other studies, because they are expressed as individuals, not indicated pairs, per 100 hectares.

Horn (2000) counted birds on 46 CRP fields in eastern and central North Dakota during 1996 and 1997. He reported the number of birds detected per point count, rather than estimated densities (birds/unit area), and found brown-headed cowbirds and clay-colored sparrows to be the most common species (Table 4).

### **Birds Favor CRP Habitats over Cropland and Certain Other Lands**

Johnson and Igl (1995) compared densities of birds in CRP fields and in croplands, the habitat replaced by CRP. Their comparison was for 1992-93 in North Dakota, when breeding birds in both kinds of habitat were surveyed. They also projected the change in population size of several species if CRP had reverted to cropland (Table 5). Most species were projected to decline in number with the anticipated loss of CRP; statewide populations of some species would decline by 15 percent or more. Analogously, in southeastern Wyoming, Wachob (1997) found higher densities of grassland birds in CRP fields and native rangeland than in croplands.

*... statewide populations of some  
[grassland bird] species would decline  
by 15 percent or more [if CRP was  
converted to cropland].*

Cunningham (2000) observed that CRP fields provided much more habitat for grassland birds in southwestern Minnesota than did public lands such as wildlife management areas, waterfowl production areas, scientific and natural areas, and state parks. The CRP fields she studied supported greater densities of certain true grassland birds, such as savannah sparrows, than did the public lands.

## Numbers of Grassland Birds Can Vary Markedly from Year to Year

It is important to recognize that the species composition of birds using CRP fields can change dramatically from year to year, depending on climatic variation, succession of vegetation communities within CRP fields, and fluctuations in the numbers and distributions of birds. Johnson et al. (1997) surveyed breeding birds annually in several hundred CRP fields in four northern Great Plains states during 1990-96. Ecological succession had taken place in those grassland habitats during that time. Also, the region was experiencing drought conditions early in the survey period, but it received above-average precipitation in the latter years of the study. Bird populations responded to these changes in different ways. While many species had similar densities in 1990-91 and 1995-96, several species increased in number fairly steadily throughout that period. They included common yellowthroat, bobolink, and clay-colored sparrow, all of which favor tall or dense vegetation (Table 6.1). After the drought terminated in mid-1993, several species increased abruptly, including northern harrier, Wilson's phalarope, and savannah sparrow, and some mushroomed, such as sedge wren and Le Conte's sparrow (Igl and Johnson 1999). Numbers of horned larks, chestnut-collared longspurs, and lark buntings tended to decline (Table 6.2). These latter species prefer sparser, more open habitat.

Also showing annual variation were Delisle and Savidge (1997), who noted that grasshopper sparrow densities declined each year in the CRP fields in Nebraska that they surveyed. They attributed that change to a buildup of litter and dead vegetation.

## The Birds Must Reproduce, Too

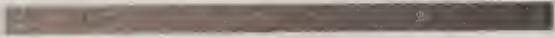
Providing habitat during the breeding season is not beneficial to birds if they are unable to reproduce successfully in that habitat. The breeding season is the part of the annual cycle that most strongly influences the population size of birds. Assessing the reproductive rate is much more challenging than determining population size; grassland birds are notoriously secretive in their breeding habits. Such behavior is necessary to avoid drawing the attention of a wide range of species that depredate nests in grasslands. Because of the difficulty of finding nests, reproductive success has not been well studied in CRP habitats in the Great Plains.

The nesting studies that have been conducted indicate that birds are at least as successful in CRP fields as in other habitats. Berthelsen and Smith (1995) found a number of nongame bird nests incidental to their upland game bird study in Texas. Most common species recorded were red-winged blackbirds, grasshopper sparrows, Cassin's sparrows, and western meadowlarks. Nest success values were higher than those typically reported in other studies in the agricultural Midwest.



Le Conte's sparrow (R. Batie)

*The nesting studies that have been conducted indicate that birds are at least as successful in CRP fields as in other habitats.*



Koford (1999) found nests of red-winged blackbirds, grasshopper sparrows, and savannah sparrows to be most common in CRP fields in his North Dakota study sites, while in Minnesota sites the most numerous species were red-winged blackbirds, bobolinks, grasshopper sparrows, and savannah sparrows. He found fledging success of ground-nesting birds in CRP fields was lower than on waterfowl production areas but not significantly so.

Clawson and Rotella (1998) studied fates of artificial nests in Montana, comparing those in CRP, linear strips of nonnative grassland (such as road-sides), and remnant patches (usually rather small) of native vegetation. They reported highest rates of nest success in CRP fields.

### **The Size of a CRP Field and Landscape Features Influence Bird Use**

*The size of a grassland patch and its surrounding landscape can markedly influence the use of that site by grassland birds.*

The size of a grassland patch and its surrounding landscape can markedly influence the use of that site by grassland birds. Some patches may be too small to be colonized by certain species, or birds using smaller patches may suffer more from competition or predation than do birds in larger patches. Also, smaller patches have a relatively greater proportion of their area near an edge, so edge effects can be more pronounced in smaller patches (e.g., Johnson, submitted). Edge effects are phenomena such as avoidance, predation, competition, or brood parasitism that operate at different levels near a habitat edge than in the interior of a habitat patch (e.g., Faaborg et al. 1993, Winter and Faaborg 1999). Brown-headed cowbirds are brood parasites; they lay their eggs in nests of other birds and leave them for the host birds to raise, usually to the detriment of the host's own young. Cowbirds use elevated perch sites to find nests to parasitize; such perches are more frequent along edges of grasslands because of the presence of trees, fence posts, and the like. Isolation from other grassland patches is a landscape feature that can affect either the use by birds or the fate of their nests in a patch.

Each of these factors—patch size, amount of edge, and isolation—can affect (1) the occurrence or density of birds using a habitat patch; (2) reproductive success, through either predation rates or brood parasitism rates; or (3) competition with other species (Johnson and Winter 1999, and Johnson, submitted).

Johnson and Igl (2001) related the occurrence of species and their densities to patch size in CRP fields. They conducted 699 fixed-radius point counts of 15 bird species in 303 CRP fields in nine counties in four states in the northern Great Plains. Northern harrier, sedge wren, clay-colored sparrow, grasshopper sparrow, Baird's sparrow, Le Conte's sparrow, and bobolink were shown to favor larger grassland patches in one or more counties. In contrast, two edge species, mourning dove and brown-headed cowbird, tended to favor smaller grassland patches.

Horn (2000) sampled 46 CRP fields in North Dakota during 1996 and 1997. He reported bobolinks, grasshopper sparrows, and red-winged blackbirds were more common in large grassland patches than in smaller ones. In contrast, brown-headed cowbirds preferred smaller fields.

In southeastern Wyoming, Wachob (1997) noted that sharp-tailed grouse favored larger CRP patches for nesting but not for brood-rearing. Also, leks were more common closer to CRP fields and in areas with extensive CRP within 0.6 mile (1 km).

## What Effect Does Haying Have?

In many counties, CRP fields have been released for haying or, less commonly, grazing in some years, due either to drought or to excessive precipitation. Johnson, Igl, and Schwartz (1998) assessed densities of breeding birds in hayed versus idled CRP the year after disturbance. Because they used the same fields in all years, they had essentially a before-and-after, treatment-and-control design. They found that a few species responded positively the year following haying. These were horned lark, chestnut-collared longspur, and lark bunting, all species that favor short and sparse vegetation. Many more species, however, responded with reduced densities the year following haying. Among these were vesper sparrow, sedge wren, common yellowthroat, bobolink, clay-colored sparrow, dickcissel, and Le Conte's sparrow.

Horn and Koford (2000) reported that sedge wrens and, possibly, clay-colored sparrows, Le Conte's sparrows, red-winged blackbirds, common yellowthroats, and grasshopper sparrows were less common in mowed than in unmowed portions of 12 CRP fields in North Dakota the year after mowing. Savannah sparrows showed the opposite tendency, being more common in the mowed portions.

## Winter Use of CRP Fields

Although the breeding season is the most critical time of year for most species, birds also need suitable habitat during the migration periods and winter. Few studies have examined bird use of CRP habitats in the Great Plains during those time periods. King and Savidge (1995) reported use in Nebraska by American tree sparrows, ring-necked pheasants, red-winged blackbirds, western meadowlarks, horned larks, and northern bobwhites. Delisle and Savidge (1997) noted only American tree sparrows, ring-necked pheasants, and meadowlarks (eastern and western meadowlarks were not distinguishable) wintering on their Nebraska study areas. For Kansas, Best et al. (1998) indicated that American tree sparrows, ring-necked pheasants, meadowlarks, northern bobwhites, and dark-eyed juncos were fairly common in CRP fields.



Nest mortality caused by haying (L. Igl)

*... a few species responded positively the year following haying. . . . Many more species, however, responded with reduced densities the year following haying.*

*Although we have learned a lot about CRP and its value to grassland birds, a number of issues merit further investigation.*

## **What Else Do We Need to Know?**

Although we have learned a lot about CRP and its value to grassland birds, a number of issues merit further investigation. Among these are landscape effects. Studies of CRP fields (Johnson and Igl 2001) and of other grassland habitats (reviewed by Johnson, submitted) have shown that patch size can influence use of grassland habitats. Also potentially important are influences of the landscape in which a CRP field is embedded. An ongoing evaluation conducted by the U.S. Geological Survey's Northern Prairie Wildlife Research Center, with support from the Natural Resources Conservation Service's Wildlife Habitat Management Institute, will relate the breeding populations of birds in CRP fields to features such as the size of the field, the area of grassland habitat (e.g., native prairie) contiguous to the field, the amount of wetland in the landscape surrounding the field, and the amount of woody vegetation near the field. It will address questions such as: Are a few larger CRP fields more beneficial to birds than several smaller fields? Does a CRP field near an already-established grassland support more birds than a similar field that is isolated? Do CRP fields near wetlands provide more benefits than those farther away? How does woody vegetation near a CRP field affect the value of the field to breeding birds?

More information is needed about specific vegetation influences. CRP plantings vary in seeding mixture, how well they germinate and persist, ecological succession, and other factors. Delisle and Savidge (1997) found in Nebraska that grasshopper sparrows and dickcissels were as common in CRP fields of cool-season grasses and legumes (CP1) as in fields of warm-season grasses (CP2). Bobolinks, however, were more common in CP1 fields, whereas common yellowthroats and sedge wrens were more common in CP2 fields. Johnson and Schwartz (1993b) indicated how several species responded to differences in vegetation composition. A study scheduled to begin in 2001 by the Northern Prairie Wildlife Research Center, with support from the U.S. Fish and Wildlife Service, will address some issues relating to planting mixtures in the northern Great Plains.

The effects of haying on the reproductive success of birds need to be determined. Johnson et al. (1998) looked at the effects of mowing on breeding populations the following year, but little is known about the total effects on reproduction during the year of mowing. It is clearly devastating to birds that are still nesting, so the actual effect depends on the date of mowing. Pressures continue to mount to mow earlier, before the quality of CRP vegetation as forage diminishes, but earlier mowing is much more detrimental to breeding birds than is mowing after most of the nesting activities have been completed.

## A Critical Concern: What's Happening with Native Prairie?

Conservation Reserve Program grassland fields are clearly much more beneficial to a wide variety of breeding birds than are the cropland fields they replaced. Tracts of untilled native prairie, however, are tremendously important to grassland birds, and support many species that rarely, if ever, use cropland or even CRP fields, such as Sprague's pipit and Baird's sparrow. Maintaining what native prairie remains should be a high priority for the conservation of birds (as well as many other animal and plant species). It is critical that farm programs do not directly or indirectly encourage conversion of native prairie to cultivation while seeking to restore perennial grassland to existing areas of cropland.

Unfortunately, evidence indicates that native grasslands are being lost at the same time as the Conservation Reserve Program is reestablishing grassland. Carl Madsen and Kurt Forman, U.S. Fish and Wildlife Service, have compiled information provided by the U.S. Department of Agriculture on grassland conversion in the northern Great Plains. In Beadle County, southeastern South Dakota, for example, they observed that between 1985 and 1995 46,810 acres (18,944 ha) were enrolled in CRP. But that change was offset by 29,561 acres (11,963 ha) of land that was newly cultivated in that county. For the state of South Dakota in total, 1,776,383 acres (718,884 ha) were enrolled in CRP by 1995. However, during that period (1985-95), 707,896 acres (286,478 ha) of grasslands were converted to cropland.

Losses of rangeland continue, and even at an accelerated pace. In Aurora County, South Dakota, newly cultivated areas totaled 185 acres (75 ha) in 1996, and increased to 2,677 acres (1,083 ha) in 2000. Tillage of rangeland is being encouraged by new varieties of crops, many of them genetically modified, such as Roundup-ready (use of trade names does not imply endorsement by the U.S. government) corn and soybeans.

Natural Resources Inventory data tell similar stories of losses of grassland. In North Dakota, rangeland diminished by 822,700 acres (332,938 ha) between 1982 and 1997; pastureland declined by 222,400 acres (90,003 ha) during the same period. Those losses probably offset many of the gains in wildlife habitat provided by the 2,801,500 acres (1,133,739 ha) enrolled in CRP in North Dakota by 1997. Similarly, losses of rangeland between 1982 and 1997 totaled 1,131,100 acres (457,745 ha) in South Dakota, 1,120,600 acres (453,496 ha) in Montana, and 546,200 acres (221,042 ha) in Nebraska. These changes in land use undoubtedly have had a negative influence on the populations of many grassland bird species.

Conservation Reserve Program fields clearly are of greater value to breeding birds in the northern Great Plains than are croplands that they replaced. Nonetheless, the continuing loss of native grasslands is a critical concern.



North Dakota CRP (USGS, NPWRC)

*... the continuing loss of native grasslands is a critical concern.*

*... [CRP] contributions would be greatly enhanced if they also discouraged further cultivation of existing grassland and fostered the preservation of that habitat.*

Those native grasslands provide habitat for a wide variety of breeding birds, including many species that do not use cropland or even CRP fields to any extent. Further, native rangeland often occurs in large patches, and thus is less susceptible to many of the problems associated with fragmentation that were described earlier. Recent farm bills make positive contributions to wildlife habitat through the Conservation Reserve Program. Those contributions would be greatly enhanced if they also discouraged further cultivation of existing grassland and fostered the preservation of that habitat. A balanced and comprehensive program is needed.

## **Acknowledgments**

I am grateful to the numerous landowners who allowed access to their CRP fields for studies reviewed here, as well as to Farm Service Agency personnel for their assistance. Carl R. Madsen and Kurt Forman generously provided information they had compiled on grassland conversion. William L. Hohman, Lawrence D. Igl, Ronald E. Kirby, and Rolf R. Koford offered valuable comments on this review.

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**Table 1. Average density of breeding birds (indicated breeding pairs per 100 ha) in Conservation Reserve Program fields, in nine northern Great Plains counties, 1990-91 average (Johnson and Schwartz 1993a).**

Species	Great Plains Roughlands			Missouri Coteau			Drift Prairie		Black Prairie
	Fallon MT	Butte SD	Hettinger ND	Sheridan MT	Kidder ND	McPherson SD	Eddy ND	Day SD	Grant MN
Lark bunting	22	34	53	56	10	19	0	0	0
Grasshopper sparrow	12	10	27	23	18	38	34	18	9
Red-winged blackbird	1	2	22	4	25	26	19	33	19
Western meadowlark	13	13	9	7	7	8	6	3	1
Horned lark	10	20	7	15	3	5	2	1	0
Savannah sparrow	0	0	9	5	6	3	8	14	12
Brown-headed cowbird	2	1	8	12	5	8	6	5	1
Clay-colored sparrow	0	0	1	6	2	2	12	12	7
Bobolink	0	0	5	2	2	2	6	10	16
Common yellowthroat	0	0	0	0	2	2	3	13	14
Sedge wren	0	0	0	0	0	0	1	10	17
Chestnut-collared longspur	0	1	3	10	2	4	0	0	0
Dickcissel	0	0	0	0	0	1	0	11	4
Baird's sparrow	1	1	0	9	1	1	1	1	0

**Table 2. Average density (pairs per 100 ha) of most common breeding birds in 30 CRP fields in western Minnesota (Hanowski 1995).**

Species	Average density
Bobolink	50
Red-winged blackbird	49
Clay-colored sparrow	38
Savannah sparrow	35
Sedge wren	26
American goldfinch	17
Brewer's blackbird	17
Common yellowthroat	16
Common grackle	13
Tree swallow	11
Brown-headed cowbird	10
Grasshopper sparrow	10
Vesper sparrow	9
Song sparrow	8
Western meadowlark	7
Mourning dove	6

**Table 3. Average density (individuals per 100 ha) of most common breeding birds in 10 CRP fields in southeastern Nebraska (Delisle and Savidge 1997).**

Species	Average density
Dickcissel	167
Grasshopper sparrow	52
Brown-headed cowbird	28
Red-winged blackbird	26
Common yellowthroat	14
Sedge wren	14
Bobolink	13
Northern bobwhite	8
Mourning dove	8
Meadowlark	8
Ring-necked pheasant	6

**Table 4. Average density (birds per 100 point counts) of most common breeding birds in 46 CRP fields in North Dakota (Horn 2000).**

Species	Average density
Brown-headed cowbird	102
Clay-colored sparrow	91
Sedge wren	78
Le Conte's sparrow	67
Savannah sparrow	59
Common yellowthroat	57
Bobolink	57
Red-winged blackbird	52
American goldfinch	17
Song sparrow	11
Grasshopper sparrow	5
Western meadowlark	5

**Table 5. Projected change in breeding population in North Dakota due to termination of Conservation Reserve Program (Johnson and Igl 1995); all counts are in 1,000s.**

Species	Population in		Change	Statewide population	Percent change
	CRP	Crop			
Lark bunting	211	21	-190	1,113	-17
Grasshopper sparrow	206	12	-193	945	-20
Red-winged blackbird	187	18	-170	1,421	-12
Savannah sparrow	94	10	-84	445	-19
Western meadowlark	80	16	-64	1,260	-5
Brown-headed cowbird	74	33	-41	1,380	-3
Bobolink	73	31	-42	388	-11
Clay-colored sparrow	54	0	-54	593	-9
Common yellowthroat	27	0	-27	286	-9
Horned lark	20	316	296	3,042	10
Sedge wren	16	0	-16	61	-26
Baird's sparrow	10	2	-8	225	-4
Dickcissel	10	1	-9	52	-17
Ring-necked pheasant	8	1	-8	84	-9
Sharp-tailed grouse	7	1	-6	88	-7

**Table 6.1. Average density (pairs per 100 ha) of breeding birds in CRP fields in northern Great Plains: species that increased in number (Johnson, Igl, and Schwartz 1997).**

Species	1990-91	1995-96
Savannah sparrow	6	20
Clay-colored sparrow	5	12
Bobolink	5	9
Common yellowthroat	4	6
Sedge wren	3	11
Le Conte's sparrow	0	16

**Table 6.2. Average density (pairs per 100 ha) of breeding birds in CRP fields in northern Great Plains: species that declined in number (Johnson, Igl, and Schwartz 1997).**

Species	1990-91	1995-96
Lark bunting	21	4
Red-winged blackbird	16	11
Horned lark	7	1
Chestnut-collared longspur	2	0
Eastern kingbird	2	1
Dickcissel	2	



# Conservation Reserve Program (CRP)

## Waterfowl Responses to the Conservation Reserve Program in the Northern Great Plains

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### Abstract

*The northern Great Plains of North America is the principal breeding area for upland nesting ducks including mallard, gadwall, blue-winged teal, northern shoveler, and northern pintail. The portion of this area called the "Prairie Pothole Region" attracts particularly large numbers of ducks during the breeding season. Extensive conversion of grasslands to cropland that has occurred since the 1960s has reduced the amount of perennial upland cover that ducks need for successful nesting; consequently, waterfowl production declined in the region. Authorization of Conservation Reserve Program (CRP) under the 1985 Food Securities Act (Public Law 99-198) allowed landowners to contract with U.S. Department of Agriculture to convert cropland to perennial cover grass in exchange for annual payments. Since the beginning of the program, more than five million acres have been enrolled in CRP in the Prairie Pothole Region. My review of published and unpublished studies clearly indicates that CRP cover is highly attractive to nesting hens and that nest success in CRP cover is higher than other common cover types. Overall, nest success in CRP fields exceeds that level considered necessary for population maintenance of the above five duck species. Waterfowl nest success in other upland nesting habitats also improved after implementation of CRP, suggesting that wildlife benefits extend beyond program areas to the entire prairie-wetland landscape. Recent research indicates that between 1992 and 1997, CRP in the Prairie Pothole Region contributed to a 30% improvement in duck production or 10.5 million additional ducks. Assuming no further conversion of grasslands to cropland, I estimate that maintenance of at least five million acres of CRP is required to achieve a positive population growth rate for waterfowl in the Prairie Pothole Region. Minor adjustments in targeting would provide additional benefits to wetland-associated wildlife.*



Blue-winged teal (W. Hohman)

## Introduction

*Concurrent with . . . grassland  
conversion to cropland  
. . . was a precipitous decline  
in duck nest success.*

The northern Great Plains region of North America is the principal breeding area for upland nesting ducks including mallard, gadwall, blue-winged teal, northern shoveler, and northern pintail (Bellrose 1976). Densities of breeding ducks are particularly high in the Prairie Pothole Region (Kantrud and Stewart 1977) where pairs are attracted to the numerous, relatively small wetlands that were formed by glacial actions that ended about 10,000 years ago (Bluemle 1991). In pristine times, the landcover of this region was dominated by perennial grasses (*Gramineae*) and broad-leaved herbaceous plants or forbs that provided ideal nesting cover for upland nesting birds, including many species of ducks (Kaul 1986). During the process of settlement by Europeans, much of the prairie sod was cultivated and converted to croplands. In North Dakota, South Dakota, and Montana, for example, 50-67% of all grasslands have been converted primarily to cropland (U.S. Department of Agriculture 1994). The conversion of grassland to cropland has been even greater in the Prairie Pothole portions of these states where less than 1% (Minnesota and Iowa) to about 26% (South Dakota) of the original grasslands remain (Cowardin et al. 1995, Noss et al. 1995). Concurrent with the period of grassland conversion to cropland in the Prairie Pothole Region was a precipitous decline in duck nest success. Beauchamp et al. (1996) concluded that duck nest success exhibited a declining trend from about 33% in 1935 to about 10% in 1992. Cowardin et al. (1985) determined that nest success of about 15% is needed to maintain mallard populations in central North Dakota; 15-20% nest success is necessary to maintain populations of other species (Klett et al. 1988). Klett et al. (1988) concluded that during the early 1980s nest success was inadequate to maintain populations for most upland nesting ducks in areas of North Dakota, South Dakota, and Minnesota, and that predators were responsible for most failed nests. It was hypothesized that long-term changes in the prairie landscape due to agriculture influenced predator demographics, and this, combined with effects of reduced amounts of grass nesting cover, was responsible for the declining trend in duck nest success. Greenwood et al. (1995) found that duck nest success on study areas in prairie Canada was negatively correlated with the proportion of land that was annually cultivated. Similarly, Ball et al. (1995) reported high duck production rates on study blocks in north-central Montana where large areas of grass remained. Wildlife managers have speculated that if a substantial amount of cropland was converted to grass cover, duck nest success would improve in the Prairie Pothole Region. Efforts by the U.S. Fish and Wildlife Service to protect and plant grass cover in the U.S. Prairie Pothole Region include over 250,000 acres of uplands on National Wildlife Refuges and Waterfowl Production Areas that are managed primarily for nesting ducks. However, many of these areas are isolated in landscapes dominated by cropland, and studies have documented low nest success on such areas (Klett et al. 1988, Sargeant et al. 1995).

Congress authorized the Conservation Reserve Program (CRP) as part of the 1985 Food Securities Act (Public Law 99-198); provisions to continue the program were included in 1990 and 1996 amendments to the 1985 Farm Bill. Under CRP, landowners contracting with U.S. Department of Agriculture to convert cropland to perennial grass or tree cover receive annual payments for 10 or 15 years. In 1993 (the peak year for cumulative enrolled acres from the 1985 Farm Bill), North Dakota had about 2.2 million acres and South Dakota and Montana each had about 1.2 million acres enrolled in the CRP within the Prairie Pothole Region (U.S. Department of Agriculture, unpublished data). In this region, most enrolled fields were planted to a mix of introduced grasses and legumes composed primarily of wheatgrasses (*Agropyron* spp.), smooth brome (*Bromus inermis*), alfalfa (*Medicago sativa*), and sweetclover (*Melilotus* spp.). In 1996, environmental criteria for ranking CRP bids were modified; expired contracts were not extended, but could be re-offered. Recent summaries of CRP acres in the Prairie Pothole Region are not available, but compared to the 1986-95 period (i.e., enrollments under 1985 Farm Bill), statewide CRP acreage increased by 14% in North Dakota and 30% in Montana, decreased by about 30% in South Dakota, and remained the same in Minnesota and Iowa (U.S. Department of Agriculture, unpublished data).

In this chapter, I summarize published and unpublished information on CRP contributions to waterfowl conservation in the northern Great Plains. I also discuss effects of emergency haying on nesting waterfowl and interrelationship of CRP to other conservation programs.

## Waterfowl Response

For a cover program to generate substantial direct benefits to nesting waterfowl it must meet three criteria: (1) provide cover that is attractive to nesting females, (2) be characterized by nest success and brood survival that is greater than other cover types in the area, and (3) be applied in areas where the cover is available to a large proportion of nesting hens.

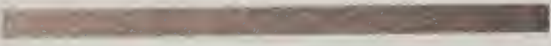
### Use of CRP Cover by Nesting Ducks

Studies have shown that idle planted cover of the type planted to CRP in the northern Great Plains is attractive to nesting ducks (Duebbert and Lokemoen 1976, Klett et al. 1988, and Greenwood et al. 1995). Klett et al. (1988) estimated for nesting mallard hens, idle perennial cover was over 100-times more attractive than cropland, four-times more attractive than hayland, and 10-times more attractive than pastureland. Other common species of upland nesting ducks demonstrated similar preferences for planted cover in the U.S. Prairie Pothole Region. Prairie nesting ducks clearly prefer undisturbed areas with tall (height  $\geq$  one foot), dense vegetation with abundant, residual plant litter (old growth vegetation from previous growing seasons). Reynolds et al. (in review) estimated that between 1992-97 an average of 2.4 million mallard,



Ducklings in nest in CRP field  
(Ducks Unlimited)

*Studies have shown . . . CRP  
in the northern Great Plains  
is attractive to nesting ducks . . .*



gadwall, blue-winged teal, northern shoveler, or northern pintail nests were initiated annually in 3.9 million acres of CRP in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana. Thus, although CRP cover represented only about 6% of all cover in the region during that period, it accounted for 31% of all nests initiated in the region.

### **Duck Nest Success**

*... duck nest success has improved since CRP was implemented in the northern Great Plains.*

Studies suggest that duck nest success has improved since CRP was implemented in the northern Great Plains. Kantrud (1993) reported average duck nest success of 23.0% for all species nesting in Minnesota and North Dakota CRP fields studied from 1989 to 1991. Luttschwager et al. (1994) reported 23.4% duck nest success (species combined) for study areas in eastern South Dakota during 1989 and 1990. Nest success in North and South Dakota CRP fields during 1992 and 1993 averaged 22% for gadwall, 24% for mallard, and 25% for blue-winged teal (Reynolds et al. 1994a).

During 1992-95, Reynolds et al. (in review) collected data for 6,945 duck nests in over 30,000 acres of CRP on randomly selected study sites in the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana. Regional estimates of duck nest success in CRP, weighted by breeding population size, were 19.3% for mallard, 22.1% for gadwall, 24.4% for blue-winged teal, 26.5% for northern shoveler, and 21.3% for northern pintail. They also found a positive relationship between nest success in CRP and the amount of perennial grass cover within their four-square-mile study areas. During this study, duck nest data also was collected from other cover types in the Prairie Pothole Region, and it was determined that nest success in all cover types increased after CRP fields were established with vegetative cover. In particular, nest success increased in planted cover on U.S. Fish and Wildlife Service, Waterfowl Production Areas during the CRP period. Reynolds et al. (in review) suggested that the addition of CRP cover resulted in greater dispersion of duck nests and increased the availability of alternative prey items for predators, thereby reducing nest losses to predators.

### **Duck Brood Survival**

If habitat conditions are favorable, early nesting duck species such as mallards and northern pintails will attempt to renest if their initial attempt is unsuccessful (Cowardin et al. 1985). However, Krapu et al. (2000) found that mallard broods that hatched earlier in the breeding season survived at a higher rate than those that hatched later. To maximize the success of hens during initial nest attempts, these authors recommended management treatments that maintain a high proportion of landscapes in undisturbed perennial cover such as CRP. Additionally, undisturbed perennial cover located in close proximity to brood-rearing wetlands likely contributes to improved survival of hens and brood hens during overland movements.

## Distribution Relative to Breeding Ducks

The distribution of CRP cover nationally and locally within the Prairie Pothole Region is a key factor for breeding ducks and other migratory birds. The Environmental Benefit Index (EBI) used to rank CRP bids includes bonus points for National Conservation Priority Areas (CPAs). Achievement of North American waterfowl conservation objectives is possible because the Prairie Pothole Region has been identified as a U.S. Department of Agriculture CPA critically important for waterfowl and other grassland-dependent birds. Local distribution of CRP contracts within the Prairie Pothole Region, especially with respect to wetlands, influences their value for waterfowl. Wetlands are the primary landscape feature that attract breeding hens to settle in a particular area (Johnson and Grier 1988), and the distribution of wetlands is not uniform throughout the Prairie Pothole Region. Whereas the EBI factors generally do not target specific wildlife groups, it is reasonable to assume that wildlife respond positively to improvements in soil and water conservation. Indeed, Reynolds et al. (1994b) reported that CRP cover targeting highly erodible lands (HEL) in the Prairie Pothole Region benefited large numbers of breeding ducks. However, they concluded that additional CRP acreage with better targeting would achieve additional soil, water, and wildlife conservation benefits.

In the Prairie Pothole Region of North Dakota, South Dakota, and northeastern Montana, I determined, that on average, about 60% of upland nesting ducks in the region had access to at least one CRP field during the period 1992-97 (Cowardin et al. 1995, R. Reynolds unpublished data). Further, we estimated that 31% (14.5 million nests) of 47.1 million total duck nests initiated in the U.S. Prairie Pothole Region during 1992-97 were located in 3.9 million acres of CRP cover or just 6% of the total land area of this region. Current distribution of CRP cover relative to duck populations and the importance of CRP relative to other upland habitats presently are unknown because of the redistribution of CRP contracts after the 1996 Farm Bill. The proportion of ducks nesting in CRP probably has declined to less than 31% because, although the availability of CRP to nesting hens in North Dakota was unchanged after 1996, it appears ducks may have reduced access to CRP in South Dakota.

## Wetland Restoration under the Conservation Reserve Program

Because the CRP is directed toward cropland, opportunities are available to restore wetlands that were drained and farmed before CRP was created. Natural Resources Conservation Service records of conservation treatments indicate that greater than 20,000 wetland acres have been restored or created in CRP fields throughout the Northern Plains states. Based on U.S. Fish and



North Dakota CRP field (R. Reynolds)

**31% . . . of 47.1 million total duck nests initiated in the U.S. Prairie Pothole Region during 1992-97 were . . . in CRP . . .**

Wildlife Service waterfowl surveys of the Northern Plains, I estimate that these wetlands have the potential to provide habitat for an additional 22,000 pairs of breeding ducks.

### Impacts of Emergency Haying

Haying, grazing, or other commercial use of CRP vegetation are not allowed during the contract period unless the Secretary of Agriculture releases it in response to drought or other agriculture emergency. Haying or grazing under the emergency clause has been allowed in some counties in Northern Plains states in all years except three since the beginning of the program.

*Haying and grazing  
reduce . . . the use  
of program fields by ducks.*



Bales of native grass (W. Hohman)

Haying and grazing reduce the amount of vegetation available to nesting ducks and, consequently, reduce the use of program fields by ducks. Because of the mechanical disturbance associated with haying, this form of use has greater negative impacts than grazing. The negative impacts of haying on nesting ducks can be placed in two broad categories: (1) catastrophic (those impacts that have an immediate negative impact) and (2) residual (delayed impacts). Catastrophic impacts recorded from hay fields include almost complete destruction of all active nests (Labisky 1957, Gates 1965) and 50% mortality in nesting hens (Calverley and Sankowski 1995). The timing of haying is critical relative to these impacts. U.S. Fish and Wildlife Service records for over 6,900 duck nests from CRP fields in the Prairie Pothole Region showed that 70% of nests were active on June 15, 33% on July 1, and 11% on July 15 (U.S. Fish and Wildlife Service, unpublished data). The residual impacts of haying CRP are manifested by reduced attractiveness to hens and sometimes lower nest success following haying. In North and South Dakota, CRP fields that had been partially hayed the previous summer, Renner et al. (1995) found no differences in duck nest success between hayed and unhayed portions of fields; however, nest and hatchling density were over two times higher in unhayed than in hayed areas. Luttschwager et al. (1994) studied duck nest success relative to different patterns of haying and found that nest success was lower in strips of CRP cover remaining after haying compared to blocks of cover.

### Summary

In general, the evidence indicates that CRP cover has directly and indirectly contributed to improved duck production in the northern Great Plains region. I estimate that between 1992 and 1997, CRP in the Prairie Pothole Region contributed to a 30% improvement in duck production or 10.5 million additional ducks. Assuming no further conversion of grasslands to cropland in the Prairie Pothole Region, we will need to maintain at least five million acres of CRP to achieve positive population growth rates in the region. Minor adjustments in targeting (e.g., giving priority to CRP contracts in the Prairie Pothole Region counties that have abundant wetlands) would provide addi-

tional benefits to wetland-associated wildlife (Reynolds et al. 1996). GIS applications have been shown to be a particularly powerful tool in determining priority locations for waterfowl and other migratory bird conservation work. Such GIS maps identifying sites with the greatest potential for wetland wildlife enhancement are available for many portions of the Prairie Pothole Region through the U.S. Fish and Wildlife Service's Habitat and Population Evaluation Team Office in Bismarck, North Dakota.

**GIS applications . . . a powerful tool  
in determining priority locations  
for waterfowl . . .**

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# Conservation Reserve Program (CRP)

## Impact of the Conservation Reserve Program on Wildlife Conservation in the Midwest

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### Abstract

*Evidence that the Conservation Reserve Program (CRP) created habitat used by grassland birds in the Midwest is unquestionable. Strong evidence that avian abundance in CRP habitats was substantially higher than in rowcrop habitats typically replaced by CRP plantings has accumulated. Additionally, reported nest abundance in CRP habitat was an order of magnitude greater than that in rowcrop sites. Nest success for birds breeding in CRP was reported to be approximately equal to, or higher than, that measured in alternative agricultural or grassland habitats. Limited evidence indicates that reproductive success and survival in CRP habitats in the Midwest were of sufficient quality to yield positive population growth for a few species (including several of high conservation concern). However, data linking the establishment of CRP habitat to positive population growth has been reported for only two grassland bird species in the Midwest. Overall, the evidence accumulated to date indicates that CRP habitat in the Midwest likely contributes to the population stability or growth of many, but not all, grassland bird species.*

### Introduction

The tallgrass prairie ecosystem dominated the Midwest landscape prior to settlement by people of European ancestry. The approximately 94 million acres of tallgrass prairie originally extant has been reduced by 83 to > 99% in midwestern states (Noss et al. 1995, Steiner and Collins 1996). Additionally, in recent years the loss of agricultural grasslands (largely nonnative grass hayfields and pastures) has been substantial (Herkert et al. 1996).

Because most of the destruction of prairie habitat occurred prior to intensive monitoring of wildlife populations, the full effect of the losses on conservation of wildlife cannot be assessed. However, Herkert et al. (1996) identified 13 species of grassland birds as threatened or endangered in eight midwestern states (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio,



Savannah sparrow feeding nestlings

Wisconsin), and another 11 species were ranked of high conservation concern. Similar, comprehensive analyses of the conservation status of other grassland wildlife taxa in the Midwest have not been attempted, but the decline of several prairie-associated mammals (e.g., bison [*Bison bison*], elk [*Cervis canadensis*], jackrabbits [*Lepus* spp.]), reptiles (e.g., massasauga [*Sistrurus catenatus*], box turtle [*Terrapene* spp.]), amphibians (e.g., spadefoot toads [*Scaphiopus* spp.]), and butterflies (e.g., Dakota skipper [*Hesperia dacotae*], Karner blue) are well known (see reviews by Arenz and Joern 1996, Benedict et al. 1996, Corn and Peterson 1996).

... birds ... offer the best opportunity  
to evaluate the impact of the CRP  
on wildlife conservation.

In the eight midwestern states previously identified, there are currently > 3.6 million acres enrolled in the Conservation Reserve Program (CRP). The vast majority of those acres were planted with grasses (> 80%). The increase in grassy habitats associated with the CRP constitutes the largest addition of grassland habitat in the Midwest since European settlement.

It was widely assumed that the establishment of CRP plantings would positively affect grassland wildlife populations (e.g., Berner 1988). Because of the more extensive background data on population status of birds in North America, those species offer the best opportunity to evaluate the impact of the CRP on wildlife conservation. The purpose of this paper is to review the evidence regarding the impact of the Conservation Reserve Program on grassland bird conservation in the Midwest.

## Birds and CRP in the Midwest

Among the intended objectives of the Conservation Reserve Program was an increase in total habitat available for wildlife, especially grassland birds. The implicit assumption underlying this objective was that grassland habitat was limiting populations of many species of birds. By establishing new grass plantings, it was expected that birds would occupy those habitats and successfully reproduce, thereby augmenting their populations. Because populations of many species of grassland birds were known to be declining (Sauer et al. 1996), the impact of the Conservation Reserve Program on wildlife conservation was projected to be substantial. Therefore, any assessment of the impact of the Conservation Reserve Program must consider how well the program provided habitat for various songbirds, whether those species successfully reproduced in CRP habitats, and whether species population declines were slowed or reversed.

To fully assess whether the Conservation Reserve Program met its objective of contributing to wildlife conservation, several levels of evidence of a positive impact on conservation of birds in the Midwest, from weakest to strongest, should be investigated. They are as follows:

- Evidence of use (occupancy) of CRP habitats;
- Evidence of high abundance in CRP relative to alternative habitats, especially croplands that were replaced by CRP;
- Evidence of nesting in CRP and comparison with alternative habitats;
- Evidence of high reproductive success relative to alternative habitats;
- Evidence of reproductive success and survival in CRP habitats sufficient for positive population growth (i.e.,  $\lambda > 1.0$ );
- Evidence of positive population growth (or reduced decline) after initiation of the CRP.

## Evidence of Bird Use of CRP Habitats

There is overwhelming evidence that CRP plantings were used by a variety of bird species. In their review of the literature, Ryan et al. (1998) listed 92 species of birds, including 53 songbirds (Order Passeriformes), that had been observed using CRP plantings in the central United States. In the most extensive study of songbird use of CRP in the Midwest, Best et al. (1997) observed over 60 species of birds using CRP habitats during the breeding season. Similarly, Best et al. (1998) recorded over 40 bird species using CRP grasslands as winter feeding or roosting habitat. Interestingly, the total number of bird species observed in CRP plantings by Best et al. (1997, 1998) did not differ markedly from the number of species they observed in nearby rowcrop fields.

## Evidence of High Bird Abundance in CRP Habitats

Best et al. (1997) compared avian abundance in paired CRP and rowcrop habitats in six midwestern states (Indiana, Michigan, Iowa, Missouri, Nebraska, and Kansas) in the early 1990s. Best et al. (1997) detected from 1.4 to 10.5 times more birds in CRP grasslands than rowcrop fields during the breeding season. Similarly, King and Savidge (1995) reported avian abundance to be four times greater in CRP habitat than croplands in Nebraska. Best et al. (1997) further reported 16 species of birds that were unique or substantially more abundant in CRP habitat than in nearby rowcrop fields. Three of the four bird species they most frequently observed in CRP (dickcissel, grasshopper sparrow, and bobolink) have been undergoing significant population declines. Additionally, Henslow's sparrow and sedge wren, species of high conservation concern in the Midwest (Herkert et al. 1996), occurred only in CRP habitat. Of the five species unique or substantially more abundant in rowcrops than in CRP habitats (Best et al. 1997) only one, the lark sparrow, is of moderate conservation concern (Herkert et al. 1996).

*There is overwhelming evidence that CRP plantings were used by a variety of bird species.*



Iowa CRP (L. Betts)

Direct comparisons of avian abundance in CRP and alternative grassland habitats have been rare. Klute and Robel (1997) documented higher abundances of dickcissels, grasshopper sparrows, meadowlarks, and upland sandpipers in grazed pastures versus CRP plantings in Kansas.

During the winter months, ring-necked pheasants, northern bobwhites, American tree sparrows, dark-eyed juncos, and American goldfinches were the most abundant or widely distributed species observed in CRP habitats (Best et al. 1998). All but the goldfinch have been undergoing long-term population declines (Sauer et al. 1996). In a separate study, Burger et al. (1994) provided evidence that CRP plantings in Missouri provided important winter cover for northern bobwhites. They documented that 69% of nighttime roosts occurred in CRP habitat in an area where CRP made up only 15% of the landscape. Rogers (1999) reported higher use of CRP habitat by ring-necked pheasant adults and young than expected based on availability in western Kansas.

### **Evidence of Nesting in CRP Habitats**

CRP plantings have been extensively used for nesting by grassland birds in the Midwest. Best et al. (1997) located 1,638 nests of 33 bird species in CRP habitat versus only 114 nests of 10 species in a similar area of rowcrops. Nests of red-winged blackbird, dickcissel, and grasshopper sparrow were the most frequently located in CRP habitat by Best et al. (1997). In rowcrop, they most frequently discovered red-winged blackbird, vesper sparrow, and horned lark nests. In northwest Texas, Berthelsen et al. (1990) found approximately six pheasant nests per 10 acres of CRP land, but no nests in cornfields. In Missouri, 55% of northern bobwhite nests and 46% of brood foraging locations occurred in CRP habitat that comprised only 15% of the largely agricultural landscape.

### **Evidence of High Reproductive Success Relative to Alternative Habitats**

Nest success of birds breeding in CRP habitat has been equal to or greater than that reported for alternative agricultural habitats. Apparent nest success for 1,526 nests monitored in CRP habitats by Best et al. (1997) was 40% versus 36% for 113 nests monitored in rowcrop fields. Using a subset of the data from Best et al. (1997), Patterson and Best (1996) reported apparent nest success of 38% in CRP habitat and 32% in rowcrop fields in Iowa. McCoy (1996), using the Missouri subset of the Best et al. (1997) data, reported significantly higher Mayfield nest success in CRP habitats versus rowcrop fields in two of three years (1993: CRP = 45%, rowcrop = 12%; 1995: CRP = 46%, rowcrop = 9%; 1994: CRP = 43%, rowcrop = 53%).

*Nest success of birds breeding in CRP habitat has been equal to or greater than that reported for alternative agricultural habitats.*

McCoy et al. (1999) further noted that reproductive success of grasshopper sparrows, field sparrows, dickcissels, American goldfinches, and common yellowthroats breeding in CRP habitat in Missouri was similar to or higher than that reported from alternative grassland habitats in a variety of prior studies. Klute and Robel (1997) compared Mayfield nest success of seven species breeding in CRP and pasture habitats in Kansas. They detected no differences; however, sample sizes of nests were very small. Granfors et al. (1996) reported Mayfield nest survival for eastern meadowlarks in CRP and grazed grassland habitats in Kansas. Nest success in CRP and grazed grass did not differ (1990: CRP = 17%, grazed = 25%; 1991: CRP = 10%, grazed = 20%), but they noted the low power of their statistical tests. Granfors et al. (1996) also reported no difference in the mean number of nestlings fledged, for radio-marked females occupying CRP and grazed habitats (CRP = 1.9 fledged/female, grazed = 0.7).

### **Evidence of Reproductive Success or Survival Adequate for Positive Population Growth**

McCoy et al. (1999) quantified seasonal fecundity for eight grassland bird species breeding in CRP habitats in Missouri and assessed whether it was adequate to offset annual mortality (i.e., achieve  $\lambda$ 's > 1.0). They concluded that CRP habitats were of sufficient quality for four species (grasshopper sparrow, field sparrow, eastern meadowlark, and American goldfinch) to produce young in excess of that needed to maintain stable populations. Common yellowthroat reproductive success in CRP habitats varied substantially among years, with output being in excess of that needed for maintenance of a stable population in only one of three years (McCoy et al. 1999). For two species (dickcissel and red-winged blackbird), production of young from nests in CRP habitat was substantially less than necessary to maintain stable populations (McCoy et al. 1999).

Patterson and Best (1996) reported apparent nest success of ring-necked pheasants breeding in Iowa CRP habitats as 34%, considerably higher than that reported for alternative agricultural habitats studied previously in Iowa (see Ryan et al. 1998 for review). The 34% rate reported by Patterson and Best (1996) exceeded the level of nest success predicted by Hill and Robertson (1988) as necessary to maintain stable populations.

No direct measures of survival of grassland birds occupying CRP habitats for all or significant portions of the annual cycle are available. However, Burger et al. (1995) did not detect a difference in annual survival of northern bobwhites occupying a landscape comprised of 15% CRP habitat (5.4%) versus an agricultural area without CRP (5.1%).



Dickcissel (D. Seaman)

***CRP habitats were of sufficient quality for four [of eight grassland bird] species . . . to produce young in excess of that needed to maintain stable populations.***

## Evidence of Population Growth Related to CRP Habitat

Based on Breeding Bird Survey data from Illinois, Herkert (1997) demonstrated a significant positive relationship between the population trend for Henslow's sparrow and the percent of CRP habitat in a county. Five of eight counties with  $\geq 3\%$  of the area in CRP habitat had positive population trends for Henslow's sparrow, whereas eight of 11 counties with  $< 3\%$  CRP had negative trends. Unfortunately, the effect of CRP habitat establishment was not sufficient to reverse the long-term declining trend in Henslow's sparrows in Illinois (Herkert 1997).

*... a greater increase  
in [population] trend slopes  
in areas with higher CRP acreages ...*

In similar analyses, Herkert (1998) reported a significant change in the slope of the population trend for grasshopper sparrows after the initiation of the CRP. In the eight years prior to the CRP, 179 (64%) of 278 Breeding Bird Survey routes had negative trends. In the eight years after, only 149 (54%) of the routes had negative trends. The overall trend prior to CRP initiation was strongly negative, but was essentially level during the CRP years. Herkert (1998) also showed a greater increase in trend slopes in areas with higher CRP acreages ( $> 3.8\%$  of the landscape).

In Minnesota, ring-necked pheasant populations tripled from the mid-1980s to the early 1990s as CRP habitat increased (WMI 1994, Ryan et al. 1998). Also in Minnesota, Kimmel et al. (1992) reported strong, positive relationships between population indices for pheasants and for meadowlarks, but not for gray partridges and percent of CRP grassland in the landscape. Pheasant populations in Nebraska increased from  $< 2$  birds/100 miles of survey route during 1983-1985 to  $> 10$  birds/100 miles in 1994 as CRP was established. King and Savidge (1995) reported significantly more pheasant observations in study areas with 18-21% CRP landscape coverage versus areas with 2-3% CRP. In Iowa, Riley (1995) compared pheasant populations in the five years immediately prior to CRP initiation with those in the first five years after establishment. He recorded a significant increase in mean detections from 37 to 48/survey route. Most the change occurred where CRP was established in landscapes initially comprised of  $> 70\%$  cropland. In contrast to these studies, Rogers (1999) reported no pheasant population response to CRP establishment in western Kansas. Similarly, Roseberry and David (1994) detected no relationship between northern bobwhite population indices and amounts of CRP in the landscape in Illinois.

## Remaining Questions

To better evaluate the impact of the CRP on wildlife conservation and to improve the efficiency (i.e., increased conservation benefits per dollar expended), several lines of additional research are needed including:

- Direct comparisons of abundance and reproductive success of species breeding in native prairie and CRP grasslands;

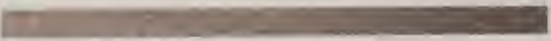
- Further evidence of population level change attributable to the availability of CRP grassland habitat at regional levels;
- The effects of distribution of CRP plantings in different landscape contexts on avian use and reproductive success in CRP fields (e.g., should CRP contracts be clumped or dispersed in landscapes with high or low amounts of existing grassland?);
- Comprehensive analyses of the impacts of types, frequency, and extent of disturbances (e.g., mowing, burning, grazing) of CRP vegetation on avian abundance and reproductive success;
- Greater focus on nonavian wildlife response to Conservation Reserve habitats.

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# Conservation Reserve Program (CRP)

## Wildlife Responses to the Conservation Reserve Program in the Southeast

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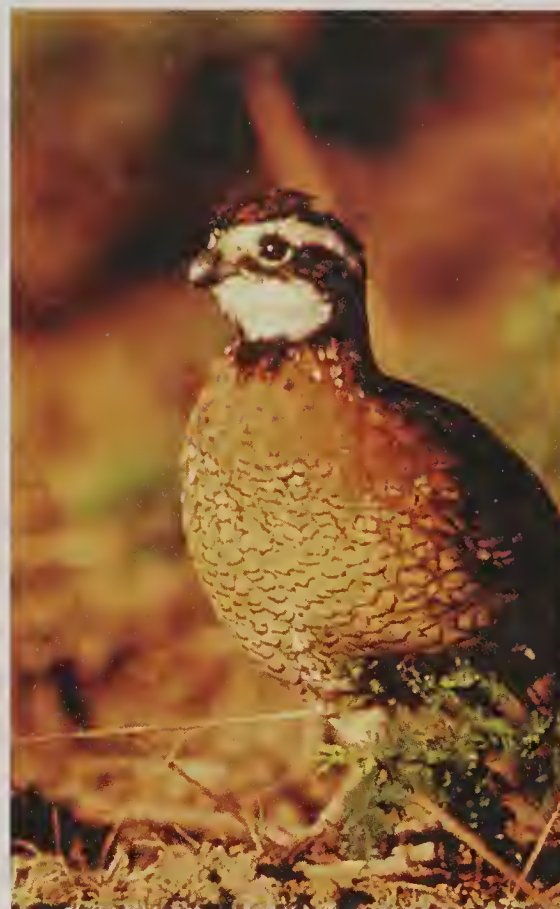
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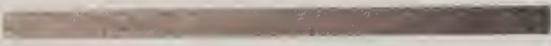
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### Abstract

Over 2.7 million acres were enrolled in the Conservation Reserve Program (CRP) in the southeastern United States in 1999, creating early successional plant communities that might provide short-term habitat for regionally declining early successional species. Rigorous evaluations of the effects of CRP on wildlife in the Southeast are lacking. However, probable impacts may be inferred from studies of wildlife response to land management practices similar to those implemented under CRP. This review examines potential wildlife benefits of CRP as indexed by avian communities. In contrast to the Midwest where grass establishment practices dominated CRP enrollment, 62% of CRP acres in the Southeast were enrolled in tree planting practices, primarily loblolly pine. The replacement of agricultural lands with tree plantings in a forest-dominated landscape (48% of landbase) may result in a long-term net loss of habitat for early successional species. During the first one to three years following establishment, pine plantations are characterized by low-growing grasses and forbs and provide habitat for grassland and early successional bird species. As the stand matures, herbaceous plants are replaced by shrubs and trees. Avian diversity increases with stand age as shrub-successional birds colonize the stand. Avian richness is lowest during mid-rotation (15-25 years) when canopy closure eliminates herbaceous ground cover. In mid-rotation, stand thinning and prescribed fire may enhance habitat quality for grassland and shrub-successional birds. Bottomland hardwood plantings established under CRP should be expected to support high densities of grassland birds during the first five years after establishment. Peak abundance of shrub-successional species will occur 7-15 years after planting. Stands > 20 years old should support 75-85% of the avian community characteristic of mature bottomland hardwoods. Interplanting of rapidly growing tree species, such as cottonwood, sycamore, or green ash, would dramatically accelerate colonization by forest bird species. In the Southeast, the wildlife habitat value of grasslands enrolled in CRP may be limited by establishment of exotic forage grasses, mowing, and the rapid rate of grassland succession. Conversion of forage grasses to native communities and implementation of management regimes that maintain



Northern bobwhite (J. M. Huspeth)



diverse annual weed communities will enhance the wildlife habitat value for early successional species. Field border practices such as CP21 and CP22 can dramatically enhance suitability of agricultural landscapes for shrub-successional species and also may increase landscape-level suitability for wintering passerines, particularly sparrows. Overall, the potential wildlife benefits of CRP in the Southeast are substantial, but they may be unrealized because of the selection of specific practices (e.g., pine plantations). Moreover, relative to the Midwest, the actual benefits of CRP in the Southeast remain unknown because of the lack of rigorous evaluation.

## Introduction

Provision of wildlife habitat is one of the intended purposes of CRP as originally conceived in the 1985 Food Security Act and amended in 1990 and 1996. Throughout the Great Plains and the Midwest, CRP has created tremendous potential wildlife habitat for grassland-dependent wildlife and at least some populations appear to have responded (e.g., Allen 1994, Ryan et al. 1998). In the Southeast, agricultural lands enrolled in CRP have the potential to provide essential early successional habitat for regionally declining grassland and shrub-successional species. However, the implementation of the program and practices established in the Southeast differ markedly from other regions and the wildlife benefits are less obvious. Consequently, evaluations of wildlife responses to CRP in the Midwest or Great Plains have little applicability to the Southeast. Regrettably, wildlife habitat value of and population responses to CRP have not been well documented in this region. However, probable impacts may be inferred from studies of wildlife response to land management practices similar to those implemented under CRP. Insofar as avian-habitat relations have been more thoroughly investigated than most vertebrate groups, and long-term population trends for birds have been indexed in a standardized fashion through the Breeding Bird Survey since 1966, this review will infer potential wildlife habitat value of CRP in the Southeast for avian communities of conservation concern. This review will provide an overview of land-use patterns and changes in the Southeast, characterize CRP in this region, and infer potential wildlife responses to the three principal conservation practices implemented in the region.

*... [CRP] practices established in the Southeast differ markedly from other regions and the wildlife benefits are less obvious.*

## Changes in Land-use Patterns in the Southeast

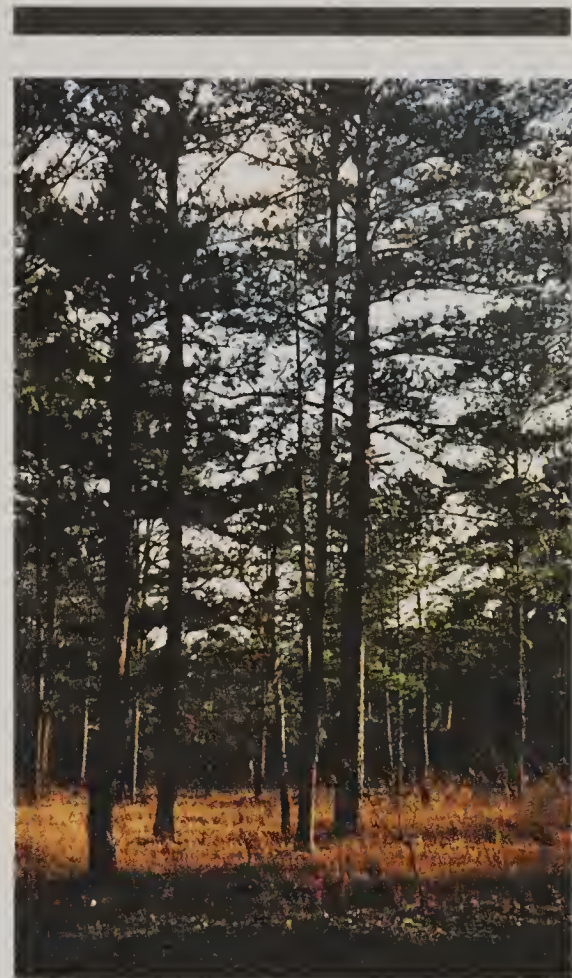
Throughout the southeastern United States, privately owned rural, agricultural, and forested lands constitute 79% of the total landbase and provide important wildlife habitats. The southeastern landscape is forest dominated, in 1997 being comprised of 48.3% forest, 14.2% rowcrops, 11.4% pasture, 1% rangeland, 1% CRP, and 3.5% other rural uses (USDA-FSA 2000). Land-use practices throughout the Southeast have changed dramatically during the previous five decades. These changes have included farm consolidation, replacement of native communities with exotic or offsite monocultures, and

conversion of agricultural lands to urban uses and forest. Based on the United States Department of Agriculture's National Resources Inventory (USDA-NRCS, NRI 1999) survey of 12 southeastern states (AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, WV), from 1982-1997, 4.7% of the rural landbase (3.9% of total surface acres) was lost to urbanization or other uses (USDA-NRCS, NRI 1999). Twenty percent of cropland (3.6 % of total landbase), 5.8% of pasture (0.7% total landbase), and 29% of rangeland (0.4% of total landbase) in these southeastern states were converted to other uses, while forested acres remained relatively stable (0.8% loss of forested acres, 0.4% of total landbase).

Simultaneously, more intensive management of remaining habitats has reduced the quality of these lands for wildlife. Mean farm size doubled and the number of farms declined by nearly 60% from 1950 to 1990. Specialized, high input, monocultural agriculture, increased field size, and elimination of idle areas have reduced the quality of agricultural lands for wildlife. Introduction of exotic forage grasses and increased grazing intensity have reduced the availability and quality of early successional habitats in agricultural landscapes. From 1982-1992, cattle numbers increased by more than 25% and cattle per 100 acres increased by 34%. Much of the existing range and pasture has been planted to nonnative forage grasses such as tall fescue, bermuda grass, and bahaia grass. Simultaneously, reduction in the use of fire has degraded the quality of remaining grasslands.


Although forested acreage in the Southeast has been stable during the past two decades, forest composition and quality have changed, reducing habitat quality for many wildlife populations. Increasing human populations combined with increasing per capita consumption of paper products have contributed to a continuously expanding demand for pulpwood. Southern pulpwood production increased more than fourfold from 1953 to 1993 and will likely continue to increase in the foreseeable future (Johnson 1996). In a 1995 survey of seven Midsouth states (Alabama, Arkansas, Louisiana, Mississippi, Oklahoma, Texas, and Tennessee), most (67%) of 40,000,000 ha of timberland was in nonindustrial private ownership (Rosson 1995). An increasing proportion of this timberland (16%) is artificially regenerated stands (plantations), mostly loblolly pine. Most (55%) plantation acreage in the Midsouth occurs on industrial forest lands with 39% on nonindustrial private lands and 7% under public ownership (Rosson 1995). In 1995, a substantial proportion (55%) of plantation acreage was in the seedling-sapling size-class. Thus, pine plantations will likely constitute an increasing component of the southern landscape and a significant proportion of early successional habitats.

Historically, the southeastern United States contained significant acreage of hardwood bottomlands, the largest occurring in the LMAV. By 1985, more



Mature Southeast pine forest  
(W. Hohman)

*Although forested acreage  
in the Southeast has been stable . . .  
forest composition and quality  
have changed . . . .*



than 80% of the original 10 million ha of forested wetlands in the LMAV had been converted to agriculture. Most of the remaining tracts of forested wetland are relatively small and highly fragmented. The quality of remaining wetlands also continues to decline due to nutrient overloading, altered hydrology, and urban development.

Although some wildlife species, such as white-tailed deer and eastern wild turkey, have thrived in modern southeastern landscapes, others have not. In particular, those species associated with grasslands, shrub-successional communities, and pine/grasslands have fared most poorly. Many of the land-use changes in agricultural and forested systems of the Southeast have resulted in the loss of early successional habitats and associated fauna. This is most clearly illustrated by population trends for the northern bobwhite (hereafter, bobwhite), ubiquitously distributed throughout the entire Southeast, but declining at a rate of 3.8%/year since 1966 (Sauer et al. 1999).

*... early successional [bird] species ...  
are declining throughout the region.*

Declines in bobwhite populations are not unique but representative of an entire assemblage of early successional species that are declining throughout the region. Breeding Bird Surveys in the Southeast during the period 1966-1998 indicate that two of four grassland birds and 16 of 23 shrub-successional species have exhibited significant declines (habitat associations as defined by Sauer et al. 1999). In contrast, forest breeding birds in the Southeast show no consistent declining pattern. During the period 1966-1998, 29% of 49 forest breeding birds in the Southeast have exhibited significant declines, whereas 31% of forest birds have exhibited significant increasing trends (Sauer et al. 1999). The notable exception is birds that breed in mature hardwood bottomland forests (Hunter 1993).

Factors contributing to declines in early successional species are complex and cumulative, attributable to the changing manner in which we as a society use our natural resources. Declines in bobwhite and grassland bird populations are not isolated but related and indicative of changes in an entire ecosystem. Loss of early successional communities and reduction in landscape heterogeneity associated with large scale, intensive, and monocultural production of agricultural and forest products are likely the direct causes of region-wide population declines of these species. Within the context of present land-use trends in the Southeast, both early successional game species and grassland/shrub-successional bird communities may benefit from identification of regional opportunities to create and maintain early successional habitats.

### **CRP in the Southeast**

Although midwestern and Great Plains states account for a significant majority of the 34 million acres enrolled in CRP, the program has had a significant effect on land-use changes in the Southeast as well. Following the 22nd CRP signup, almost 2.8 million acres were enrolled in CRP in 12 southeastern states (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North

Carolina, South Carolina, Tennessee, Virginia, and West Virginia) (Table 1). Conservation practices: CP1 (cool-season grasses), CP2 (native warm-season grasses), CP3 (trees), CP4 (wildlife habitat), CP10 (existing grasses), CP11 (existing trees), CP21 (filter strips), and CP22 (riparian buffers), collectively accounted for 97.6% of all enrolled acres. In contrast to the Midwest where grass establishment was the predominant conservation practice, tree planting (CP3 and CP11) was the most commonly selected conservation practice in the Southeast, accounting for 61.9% of total enrolled acres. Current enrollment in tree planting practices is approximately equitably distributed between newly established stands (< 15 years old, 43.7%) and reenrolled stands (52.2% > 10 years old). The most commonly established tree species was loblolly pine, although a longleaf pine National Conservation Priority Area (CPA) was established beginning with 18th CRP signup. The longleaf pine CPA included parts of nine southeastern states and provided special incentives (increased Environmental Benefits Index and exemption from Highly Erodible Lands requirements) for establishment of longleaf pine on eligible cropland. Through the 22nd CRP signup, 168,541 acres of longleaf have been enrolled in this CPA. Grass cover practices currently account for 33.1% and field border practices (CP21, CP22) 2.6% of CRP acreage in the Southeast. The distribution of enrollment between grass and tree practices differed substantially among southeastern states. Georgia and Florida enrolled almost exclusively trees (92.3%), whereas Kentucky, Tennessee, and West Virginia enrolled predominantly grasses (90.9, 85.9, 80.9%, respectively). As a result of strong involvement by state wildlife agencies, native warm-season grasses were more widely adopted in Virginia (9.5% of enrolled acres) and Kentucky (7.0% of enrolled acres), but < 1% were implemented in other states (e.g., Florida 0.1%, Mississippi 0.2%). Field border practices (CP21 and CP22) were extensively used in Kentucky (5.6% of enrolled acres), North Carolina (12.3% of enrolled acres), and South Carolina (11.1% of enrolled acres), but seldom used in Florida (0.1%), Georgia (0.3%), or Louisiana (0.3%). Thus, CRP in the Southeast is quite different from that in other regions and tremendous variation exists among southeastern states as a result of differing land use and conservation goals and potentials.

## Wildlife Responses

Evaluation of wildlife responses to CRP in the Southeast has not been as extensive, nor as thorough as in the Midwest. In fact, few studies have directly monitored wildlife populations on CRP fields and even fewer have documented population performance. However, numerous studies throughout the region have characterized wildlife populations on nonCRP lands established with management practices similar to those implemented under CRP (e.g., pine plantations, hardwood afforestation). As such, much of the inference that follows is based on observed wildlife responses to management regimes available under CRP, but not necessarily observed on lands enrolled in the program.

*Evaluation of wildlife responses  
to CRP in the Southeast  
has not been . . . extensive . . .*

Bird populations are sensitive to changes in land-use practices. Long-term population trends for birds have been indexed in a standardized fashion through the Breeding Bird Survey since 1966, thus avian assemblages of special conservation concern can be identified (Sauer et al. 1999). Moreover, avian-habitat relations have been more thoroughly investigated than most vertebrate groups. Therefore, within a given region, probable avian communities can be predicted for a given plant community. This review will infer potential wildlife habitat value of CRP in the Southeast for avian communities of conservation concern. Insofar as CRP in the Southeast, to this point, has largely created various types of grassland, shrub, or early successional forested habitats, the two avian species assemblages most likely to benefit from CRP are those associated with open-land habitats and shrub-successional habitats. In the forest/agricultural landscapes of the Southeast, early successional bird species occur as two overlapping groups occupying two distinct types of habitats. Open-land habitats created by rowcropping, pasture management, or CRP grasslands may be occupied by grassland species, but also will support successional-scrub species. The shrub-successional species may occur in agricultural ecosystems, but are more commonly associated with early seral stages of forested habitats. Both grassland and shrub-successional species have exhibited declining population trends since 1966 and are of special conservation concern. This review will focus on probable value of CRP in the Southeast for avian communities associated with grassland or shrub-successional habitats.

## **Wildlife and Tree Planting Practices**

### **Pine Plantations**

*Avian community composition  
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competition control methods.*

Avian community composition in regenerating pine stands is largely a function of stand age, site preparation methods, and competition control methods. In loblolly pine plantations, overall avian diversity and species richness tend to increase with age, although diversity may decline during the late sapling early/pole stage (Johnson and Landers 1982, Dickson et al. 1993), then increase as the stand approaches sawtimber (Darden et al. 1990). Similarly, in slash pine plantations of Florida, Repenning and Labisky (1985) reported that breeding bird abundance, species richness, and diversity were correlated with stand age. In general, avian abundance increases with age until canopy closure at 7-9 years, then declines through the early pole stage (Darden et al. 1990, Dickson et al. 1993). Although in Virginia, Childers et al. (1986) reported that total avian abundance and species richness was greater in 2- to 5-year-old pine plantations than in 7- to 24-year-old plantations.

#### *Effects of stand age*

Recently established pine plantations are characterized by low-growing grasses and forbs. Dickson et al. (1993) reported that grassland and early successional bird species, such as eastern meadowlarks, eastern bluebird, Bachman's sparrow, bobwhite, and mourning dove, are the most abundant

species during this establishment period. As the stand ages, herbaceous plants are replaced by shrubby species and height and structural complexity increases. These vegetational changes are accompanied by corresponding changes in the avian community. Grassland and early successional bird species such as meadowlark and bobwhite decline, and shrub-successional species such as indigo bunting, yellow-breasted chat, common yellowthroat, and prairie warblers increase, peaking 3-10 years following establishment. As the stand matures, grassland birds disappear, shrub-successional species decline, and forest birds such as red-eyed vireos, white-eyed vireos, pine warblers, Carolina wrens, and hooded warblers begin to permanently occupy the site (Dickson et al. 1993). The short-term overlap between the grassland/shrub-successional bird species and the forest species produces the high species richness prior to the pole stage (occurring during mid-rotation, characterized by close canopy, low plant species diversity, little herbaceous ground cover). The early successional species decline following canopy closure leaving the early colonizing forest bird species. This pattern of colonization/extinction contributes to the reduced species richness associated with pole-aged stands. Although total avian diversity increases with age of plantations, diversity and abundance of regionally declining grassland and early successional species will decline with stand age.

Some early successional species, such as bobwhite, mourning doves, eastern bluebirds, and meadowlarks, may occur both in very young plantations (1-2 years) and in mature open, pine/grasslands (Repenning and Labisky 1985). As an example, in South Carolina, Bachman's sparrows were relatively abundant in 1- to 3-year-old replanted clearcuts and mature (> 80 years) stands but occurred in low density in young plantings (6-12 years) and middle-aged (22-50 years) stands (Dunning and Watts 1990). The ground cover and understory composition and structure of mature, fire-maintained stands provides the herbaceous and shrub communities utilized by many grassland and shrub/successional bird species. Thus, as stands reach economic or ecological maturity, they may once again provide habitat for grassland/shrub-successional species, particularly if thinned and burned. The recolonization by early successional species may be accelerated by thinning and burning, thereby enhancing the herbaceous and shrub ground cover.

#### *Effects of site preparation and seed bank*

Site preparation methods affect seed bank availability and germination of competing plant species. In studies of forest regeneration, site preparation method has been shown to influence avian communities through effects on vegetation composition and structure. In South Carolina, two-year-old plantings treated with hexazinone had greater abundance of eastern bluebirds and mourning doves than mechanically treated (e.g., push-pile-and-burn, roller-chopping, and/or disking) plantations. Conversely, yellow-breasted

***Although total avian diversity increases with age of plantations, diversity and abundance of . . . grassland and early successional species will decline with stand age.***



Early successional Southeast forest  
(J. Thompson)

*... cropping history [of CRP]  
... influence[s] the developing plant  
community and subsequently  
the avian community.*

chats were more abundant on mechanically treated sites (O'Connell and Miller 1994). Although total avian abundance was similar between treatments, avian diversity was greater on herbicide-treated sites. Similarly, Darden et al. (1990) reported greater avian diversity and abundance in Mississippi pine plantations treated with herbicide than those mechanically treated. Insofar as CP3 plantings represent afforestation (establishment of trees on sites with no recent history of forest cover) as opposed to reforestation (reestablishment of trees following clear-cutting), there is no below-ground root biomass or seeds of woody species to accelerate colonization by woody species. On CP3 sites, the seed bank will reflect the agricultural history (agricultural grasses and weeds) and colonization by woody forest species will likely be slower than that experienced on regeneration sites (clearcuts). This cropping history lands will influence the developing plant community and subsequently the avian community. Therefore, during the establishment phase, avian communities on CP3 plantings will likely be more similar to grassland agricultural sites than naturally or artificially regenerated forest sites.

#### *Effects of mid-rotation management*

CRP participants that wished to re-enroll CP3 pine tree plantings (as CP11) had the opportunity to increase their Environmental Benefits Index and hence their probabilities of having their bid accepted, by agreeing to thin and prescribe burn the pine planting during the second contract period. Although avian diversity in pine plantation tends to decline during the mid-rotation period, thinning and burning may enhance habitat quality for many early successional species. For example, Bachman's sparrows typically occur in both mature pine forests with scattered shrubs and extensive herbaceous ground cover and in recently regenerated pine stands (1-5 years). Previous studies had reported Bachman's sparrows were absent from pine plantations during mid-rotation. However, in northern Florida, Bachman's sparrows extensively used mid-rotation (17- to 28-year-old) slash pine stands that had been thinned (Tucker et al. 1998). Bachman's sparrows were more abundant in thinned plantations that had been burned than in similar-aged stands that were unburned. An ongoing study in central Mississippi is examining breeding bird abundance in 24 thinned mid-rotation (19-23 years old) loblolly pine plantations under four different management regimes (thin only, thin/burn, thin/Arsenal herbicide, thin/Arsenal herbicide/burn). During the first breeding season following treatment application, 30-39 breeding bird species were observed in these stands, including 14 shrub-successional species (L. W. Burger unpublished data). Breeding bird diversity was greatest in control (thin only) plots and lowest in herbicide-only treatments. However, as the herbaceous community recovers following herbicide and fire treatments, more early successional bird species might colonize these sites. In Georgia, avian species richness and diversity in CP11 pine plantations that were thinned (30% row

thinning or 20% strip-thinning plus 33% row thinning) increased during the second growing season following thinning (Schaeffbauer 2000). During the year of thinning and the second growing season following thinning, 30 species were detected in these CP11 stands. The most abundant species were northern cardinal, indigo bunting, pine warbler, Carolina wren, and Carolina chickadee. During the second season following treatments, indigo buntings were more abundant in the strip plus row-thinned stands than in unthinned control stands. During the year of thinning, shrub-nesting species were less abundant in the strip- plus row-thinned stands than other treatments (Schaeffbauer 2000). Total relative abundance (indexed by point counts) in CP11 stands, under all treatments, was relatively low, ranging from 0.22 to 2.0 birds/ha and did not differ among treatments.

*Pine plantation summary*

In summary, pine plantations created under CRP can be expected to support populations of regionally abundant and stable forest bird species such as northern cardinal, Carolina wren, pine warbler, and indigo bunting. Furthermore, these stands will provide some short-term habitat for regionally declining grassland and shrub-successional bird species. However, these habitats will be quite ephemeral, lasting just 1-2 years for grassland birds and 3-10 years for shrub-successional species. Although an understanding of bird responses to management in pine plantations is still incomplete, thinning and prescribed fire may enhance the conservation value of these stands for grassland/shrub-successional bird species.

**Hardwood Plantations**

Bottomland hardwoods are regionally scarce forest communities in the Southeast. Hardwood bottomlands support a particularly diverse avian community (> 70 species), including numerous Neotropical migrants of international conservation concern. Conservation of the bottomland hardwood ecosystem has been given highest priority for avian conservation in the Southeast (Hunter et al. 1993). Numerous public, private, and interagency groups have identified restoration of hardwood bottomland as a conservation priority (Myers 1994). Although hardwood plantings were a relatively small proportion of the total CP3 enrollment and are a minor component of all plantations in the South (Rosson 1995), they were an eligible CRP practice (CP3b or CP22) and were commonly established under the Wetlands Reserve Program. Through assistance programs such as CRP and WRP more than 100,000 ha of bottomland hardwood are expected to be restored within the Lower Mississippi Alluvial Valley (LMAV). Although no studies have directly assessed avian response to bottomland afforestation under CRP, several recent studies have evaluated avian use, abundance, and productivity on afforestation sites similar to CRP/WRP plantings.

*... bottomland hardwood ecosystem  
has been given highest priority  
for avian conservation ...*



Midsuccessional Southeast forest  
(J. Thompson)

*... within 20 years after planting,  
hardwood plantations are supporting  
many species characteristic  
of natural sawtimber stands.*

### *Effects of stand age*

During the first four years after establishment, hardwood plantings support high densities of grassland birds such as red-winged blackbirds and dickcissels and also may be occupied by northern bobwhite, eastern meadowlark, and northern mockingbirds (Nuttall and Burger 1996). Peak abundance of shrub-successional species, such as yellow-breasted chat, indigo buntings, common yellowthroat, occur 7-15 years after planting. However, with the exception of indigo bunting, none of the previously identified species persist in plantations that are 21-27 years old (Nuttall and Burger 1996). Thus, hardwood plantings established for bottomland hardwood conservation will provide only temporary (4-15 years) habitat for some regionally declining grassland and shrub-successional species.

The long-term objective of hardwood bottomland afforestation is to produce a forest that is similar in structure and function to unaltered, mature hardwood bottomlands. When compared to mature bottomland hardwood forests, Morisita's index of similarity was 2.6-4.6% for plantations 0-4 years old, 35-42% for plantations 7-15 years old, and 74-85% for plantations 21-27 years old (Nuttall 1997). Thus, within 20 years after planting, hardwood plantations are supporting many species characteristic of natural sawtimber stands. However, much of this similarity is attributable to high abundance of many habitat generalists, including Carolina wren and northern cardinal. Older plantations still lacked certain species that are considered area-sensitive (require large tracts of forested habitat) or require late successional forest (Nuttall and Burger 1996). Twedt and Portwood (1997) suggested that the addition of fast-growing, early successional species, such as cottonwood, willow, sycamore, and green ash, to oak plantings would accelerate the development of a three-dimensional forest structure and facilitate earlier colonization by forest bird species. They reported that 5-7 years after planting cottonwood plantations supported 36 species of birds, including forest birds such as yellow-billed cuckoo, Acadian flycatcher, yellow-breasted chat, warbling vireo, indigo bunting, orchard oriole, and Baltimore oriole. Conversely, 6-year-old oak plantings only supported nine species that were mostly grassland species such as dickcissel, red-winged blackbird, and eastern meadowlark. Cottonwood stands 5-9 years old support greater species richness (16.7) and territory density (411.9/100 ha) than similar aged oak plantings (species richness 8.1, territory density 257.3/100 ha) (Twedt et al. in press a).

The "conservation value" of a given hardwood planting has been indexed by weighting measures of avian abundance with a measure of species-specific regional conservation value (Partners in Flight conservation scores) (Nuttall 1997). Indexed in this manner, hardwood plantings 0-4 years old provide 34% the conservation value of mature, natural hardwood bottomlands.

Plantings 7-15 years old provide 46% and plantings 21-27 years old provide 65% the conservation value of mature, natural bottomlands. Highest-priority species are most abundant in natural forest stands, thus mature natural stands have the greatest conservation value. Newly established hardwood plantings are relatively species poor, and the species present in this age class are relatively common species like red-winged blackbird and eastern meadowlark. Restoration plots 11-12 years old are populated by a few high-priority shrubland birds, such as yellow-breasted chat and painted bunting, and high-priority grassland bird species such as dickcissel and consequently will have intermediate conservation value. As restoration stands reach 22-27 years old, they will be populated by high-priority forest species such as prothonotary warbler and yellow-billed cuckoo, contributing to their increased conservation value (Nuttle 1997). Similarly, Twedt et al. (in press *a*) indexed conservation value of oak plantings 5-9 years old and cottonwood plantings 0-4 and 5-9 years old by weighting territory density (territories/100 ha) by Partners in Flight prioritization scores. They reported that the conservation value of 5- to 9-year-old cottonwood stands were generally twice as large as those of oak stands less than 10 years old. Younger cottonwood stands had conservation values intermediate between oak-dominated and older cottonwood stands.

Avian productivity in hardwood plantings has received less research focus than avian abundance and species composition. Twedt et al. (in press *b*) reported that in the Lower Mississippi Alluvial Valley, daily nest survival of blue-gray gnatcatcher, eastern towhee, indigo bunting, northern cardinal, and yellow-bellied cuckoo was similar between mature bottomland hardwood forests and cottonwood plantations. However, mean daily survival of 19 nesting birds in natural bottomland hardwoods was greater than 18 species in cottonwood plantations. Differences in daily nest survival between habitats were attributed to elevated levels of nest predation and parasitism in managed cottonwoods.

#### *Hardwood plantation summary*

In summary, hardwood bottomlands are a regionally scarce resource of the highest priority for conservation of avian diversity. Over time, hardwood plantings established under CRP will likely provide substantial benefits for conservation of high priority forest bird species. Colonization of hardwood plantings by forest birds may be accelerated by interplanting with fast-growing early successional species such as cottonwood. During the first five years after establishment, hardwood plantings will provide ephemeral habitats for regionally declining early successional grassland and shrub-successional species and thus contribute to regional avian conservation.

***Over time, hardwood plantings established under CRP . . . provide substantial benefits for conservation of high priority forest bird species.***



Native grass planting (W. Burger)

## Wildlife and Grassland Plantings

Avian communities in grasslands created under CRP have received little research attention in the Southeast. This is in part because the Southeast has relatively few breeding grassland bird species and also because grassland practices are a relatively small component of total CRP enrollment. However, grasslands created under CRP may provide regionally scarce resources for grassland and early successional bird species during both the breeding and winter seasons. Bird use of these grasslands will likely be influenced by the type of cover established, the age of the stand, and the management regime implemented over the life of the contract (Burger et al. 1990).

### Effects of Grassland Cover Type

Throughout the Southeast, much of the CP1 and CP10 acreage was established in exotic forage grasses such as Kentucky tall fescue, Bermuda, or bahaia grass. Barnes et al. (1995) reported that tall fescue fields in Kentucky had dense vegetation with little bare ground and low plant species diversity. Furthermore, they observed that fescue stands provided few food resources for granivorous birds. Although tall fescue supported abundant and diverse insect communities, these food resources likely were unavailable to breeding bobwhites or their broods because of the dense vegetation structure. They concluded that tall fescue provided poor habitat for bobwhites because it lacked the proper vegetation structure, floristic composition, and sufficient quality food resources. CRP fields revegetated through natural succession or with planted native species may provide better wildlife habitat than those established in exotic forage grasses.

Program participants interested in reenrollment of grass CRP contracts could increase their Environmental Benefits Index scores by enhancing the wildlife habitat value of the existing cover. Washburn et al. (2000) evaluated efficacy of various combinations of glyphosate and imazapic herbicides in eradicating tall fescue and establishing native warm-season grasses. They assumed that reductions in fescue coverage, establishment of native warm-season grasses, increases in plant species richness, and increases in bare ground were beneficial to bobwhites. They reported that one year after treatment all herbicide treatments reduced fescue coverage and enhanced bobwhite habitat quality relative to control plots. Furthermore, the spring burn, followed by imazapic application and seeding of native warm-season grasses treatment was most efficacious in eliminating fescue and establishing native warm-season grasses.

### Effects of Age of Stand

Plant communities on CRP grasslands are not static, but rather change in species composition and structure over the 10-year life of the contract. McCoy et al. (in review) studied vegetation changes on 154 CRP grasslands in northern Missouri and reported that during the first two years following

*Plant communities on CRP grasslands  
... change in ... composition and  
structure over the 10-year life  
of the contract.*

establishment, fields are characterized by annual weed communities with abundant bare ground and little litter accumulation. Within 3-4 years, CRP fields became dominated by perennial grasses with substantial litter accumulation and little bare ground. They suggested that vegetation conditions 3-4 years after establishment might limit the value of enrolled lands for many wildlife species and some form of disturbance such as prescribed fire or disking might be required to maintain the wildlife habitat value of CRP grasslands.

### Effects of Management Regime

Mowing or clipping is the most common management practice implemented on CRP grasslands. McCoy et al. (in review) reported that mowing had short-term effects on vegetation structure (reduced height within the year and increased litter accumulation) and resulted in accelerated grass succession and litter accumulation. As a result of longer growing seasons and greater rainfall, the rate of natural succession on CRP grasslands throughout the Southeast likely exceeds that observed in the Midwest, making planned disturbance even more important for maintaining habitat quality for early successional species.

Madison et al. (1995) examined the effects of fall, spring, and summer disking and burning, and spring herbicide (Roundup) treatments on bobwhite brood habitat quality in fescue-dominated, idle grass fields in Kentucky. They reported that during the first growing season following treatment, fall disking significantly enhanced brood habitat quality by increasing insect abundance, plant species richness, forb coverage, and bare ground relative to control plots. However, the benefits of disking were relatively short-lived, with diminished response during the second growing season. During the second growing season following treatment, herbicide treatments provided the best brood habitat quality. Greenfield (1997), examining the effects of disking, burning, and herbicide on bobwhite brood habitat in fescue-dominated CRP fields in Mississippi, likewise reported that disking and burning benefited bobwhite broods during the first growing season after treatment. However, the benefits were short-lived (one growing season). Herbicide treatment in combination with prescribed fire enhanced quality of bobwhite brood habitat for the longest duration.

### Winter Bird Communities

Our understanding of bird responses to CRP is mostly based on studies of grassland birds conducted in midwestern and Great Plains states during the nesting season (summarized in Allen 1994, Ryan et al. 1998). Numerous temperate nesting, migrant grassland bird species (e.g., sparrows) winter in the Southeast and grasslands created under CRP potentially provide substantial benefits for these wintering populations. Unfortunately, use of CRP by nonbreeding grassland birds has not been assessed in the Southeast.

*... the rate natural succession on CRP grasslands throughout the Southeast ... exceeds that observed in the Midwest, making planned disturbance even more important for maintaining habitat quality for early successional species.*

## Grassland Summary

In summary, there is little information on responses of grassland-dependent birds to CRP in the Southeast; although several studies (Barnes et al. 1995, Madison et al. 1995, Greenfield 1997, Washburn et al. 2000) have assessed the suitability of CRP grasslands or similar habitats for bobwhites. The primary conclusions of these studies were that (1) the habitat value of fields established in exotic forage grasses is low, and (2) periodic disturbance is necessary to enhance or maintain quality early successional habitats.

## Wildlife and Field Border Practices

Field margin practices (filter strips and riparian corridors) constituted a relatively small (2.6%) component of CRP in the Southeast, but may provide substantial benefits for wildlife in intensive agricultural systems. Although no study has directly evaluated wildlife population response to CP21 or CP22, several studies in North Carolina have evaluated use of fallow field borders by bobwhite and passerines. Results of these studies may have application to field margin, noncrop vegetation created under CP21 or CP22. Puckett et al. (1995) examined habitat use and reproductive success of radio-marked bobwhites on four farms in Dare County, North Carolina. On two of these farms, 9.4 m wide, fallow vegetative filter strips were established along field borders and ditch banks. Spring capture rate of bobwhite and number of nests/female were greater on sites with filter strips, but nest success did not differ. Bobwhite on nonfilter strip sites exhibited greater movement from capture to first nest location. Filter strips increased use of rowcrop fields by bobwhite throughout the breeding season. In a related ongoing study of 24 farms in North Carolina, farms with filter strips ( $n = 12$ ) supported higher bobwhite density in fall than farms without filter strips (Bill Palmer, Tall Timbers Research Station, personal comm.). Filter strips apparently benefited bobwhite populations by increasing usable space during the early breeding season, holding bobwhite on the landscape until cover in crop fields developed, increasing access and use of crop fields by bobwhite, and providing nesting and brood-rearing habitat.

*Field borders also may produce substantial benefits for breeding and wintering passerines.*

Field borders also may produce substantial benefits for breeding and wintering passerines. During 1997 and 1998, fields on farms in the coastal plain of North Carolina with field borders ( $n = 4$ ) supported greater abundance of wintering sparrows than fields on farms with mowed field margins or no borders ( $n = 4$ ) (Marcus et al. in press). Sparrows commonly detected in field borders were song sparrow, swamp sparrow, field sparrow, chipping sparrow, white-throated sparrow, and dark-eyed juncos. Field borders supported a mean 34.5 sparrows/ha, whereas mowed field margins averaged 12.9 sparrows/ha. Field borders also may increase use of interior portions of fields. For example, they may enhance the habitat value of agricultural fields by providing thermal and escape cover, increasing access to food resources in crop

stubble, and increasing the proportion of agricultural landscapes available for use by grassland birds.

## Overview

Most of the 2.7 million acres of CRP in the Southeast was enrolled in tree planting conservation practices. Although systematic evaluations of wildlife benefits of CRP in the Southeast are lacking, probable patterns of wildlife occupancy and use may be inferred from studies of similar management practices on nonCRP lands. In contrast to the Midwest where grass establishment practices dominated CRP enrollment, 62% of CRP acres were enrolled in tree planting practices, primarily loblolly pine, in the Southeast. During the first 1-3 years following establishment, pine plantations are characterized by low-growing grasses and forbs and provide habitat for grassland and early successional bird species. As the stand matures, herbaceous plants are replaced by shrubs and trees. Avian diversity typically increases with stand age as bird species associated with shrubs colonize the stand. During the pole stage (mid-rotation 15-20 years) when canopy closure eliminates herbaceous ground cover, avian richness generally declines. In mid-rotation stands (15-20 years), thinning and prescribed fire may increase herbaceous ground cover, thereby enhancing habitat quality for grassland and shrub-successional birds. Bottomland hardwood plantings established under CRP should be expected to support high densities of grassland birds during the first five years after establishment. Peak abundance of shrub-successional species will occur 7-15 years after planting. Stands over 20 years old should support 75-85% of the avian community characteristic of mature bottomland hardwoods. Interplanting of rapidly growing tree species, such as cottonwood, sycamore, or green ash, would dramatically accelerate colonization by forest bird species.

In the Southeast, the wildlife habitat value of grasslands enrolled in CRP may be limited by establishment of exotic forage grasses, mowing, and the rapid rate of plant succession. Conversion of forage grasses to native communities and implementation of management regimes that maintain diverse annual weed communities will enhance the wildlife habitat value for early successional species such as bobwhite.

Field border practices such as CP21 and CP22 can dramatically enhance suitability of agricultural landscapes for shrub-successional species such as bobwhite and also may increase landscape-level suitability for wintering passerines, particularly sparrows.

Overall, the potential wildlife benefits of CRP in the Southeast are substantial, but they may be unrealized because of the selection of specific practices (e.g. pine plantations and exotic forage grasses). Moreover, relative to the Midwest, the actual benefits of CRP in the Southeast remain largely unknown because of the lack of rigorous evaluation.



Bobwhite chick (J. M. Huspeth)

*Overall, the potential wildlife benefits of CRP in the Southeast are substantial, but they may be unrealized because of the selection of specific practices . . .*

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Table 1. Acres enrolled in the Conservation Reserve Program in 12 southeastern states, following CRP signup 22, March 2000, by predominant conservation practices (USDA-FSA 2000).

State	Conservation practice <sup>a</sup>										Trees	Practices	Border	%	Total
	CP1	CP2	CP3	CP4	CP10	CP11	CP21	CP22	Grass						
									Practices	%					
Alabama	21,194	2,442	136,695	7,880	117,485	167,881	330	1,498	149,001	32.6	304,576	1,828	0.4	457,415	
Arkansas	8,252	928	37,580	3,162	28,944	50,700	1,151	2,030	41,287	28.5	88,281	3,181	2.2	144,933	
Florida	1,243	5	27,673	3,401	1,850	52,559	0	67	6,500	7.5	80,232	67	0.1	86,889	
Georgia	3,298	341	142,847	6,951	7,875	120,990	437	354	18,466	6.5	263,838	791	0.3	285,771	
Kentucky	80,685	17,208	5,157	546	146,168	1,445	13,992	972	244,608	90.9	6,602	14,964	5.6	269,165	
Louisiana	2,053	1,641	94,932	2,817	19,216	37,830	230	236	25,729	14.2	132,762	466	0.3	181,819	
Mississippi	21,381	272	283,746	9,521	130,441	316,412	2,435	11,333	161,615	20.4	600,159	13,768	1.7	792,041	
North Carolina	6,741	1,120	14,189	2,775	17,628	38,729	3,547	8,117	28,265	29.9	52,918	11,664	12.3	94,643	
South Carolina	1,388	40	48,327	11,643	12,173	103,915	3,549	19,057	25,246	12.4	152,243	22,607	11.1	203,843	
Tennessee	54,877	9,974	12,175	5,116	129,467	16,090	2,710	463	199,435	85.9	28,266	3,173	1.4	232,147	
Virginia	7,320	2,351	4,052	967	14,171	13,886	264	827	24,810	56.2	17,939	1,092	2.5	44,125	
West Virginia	10	22	134	0	771	9	12	33	803	80.9	143	46	4.6	993	
Total	208,445	36,348	807,512	54,783	626,193	920,451	28,660	44,993	925,769	33.1	1,727,963	73,653	2.6	2,793,791	

<sup>a</sup>Conservation practices: CP1, cool-season grasses; CP2, native warm-season grasses; CP3, trees; CP4, wildlife habitat; CP10, existing grass; CP11, existing trees; CP21, filter strips; and CP22, riparian buffers.

<sup>b</sup>NWSG = Native warm-season grasses



# Continuous Enrollment Conservation Reserve Program

## The Value of Buffer Habitats for Birds in Agricultural Landscapes

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### Abstract

*Conservation buffers, implemented through the Continuous Enrollment Conservation Reserve Program, are very actively promoted by the USDA under the Buffers Initiative. The best indication of how wildlife populations may be influenced by this program is provided by studies of bird communities in various strip-cover habitats. Bird abundances and nest densities are higher in strip-cover than in block-cover habitats, although nest success in the former is often very low. Birds' use of habitats depends upon vegetation structure (height and density) and species composition (herbaceous vs. woody, grass vs. forb, native vs. introduced). Some bird species are limited by the width of strip-cover habitats, thus there is a positive relationship between bird species richness and strip-cover width. Contributing to this may be the aversion that some bird species have for habitat edges. Vegetation management practices (e.g., mowing and grazing) influence bird communities both directly and indirectly. The amount of grassland surrounding herbaceous strips influences the occurrence and nesting success of birds in the strip cover. Rates of nest predation and brood parasitism by brown-headed cowbirds increase near wooded edges. Because some strip-cover habitats may function as ecological traps, there is an urgent need to identify and evaluate bird source and sink sub-populations in agricultural landscapes. Land-use decisions may vary depending upon wildlife management objectives, thus planning and evaluation of buffers will require a clear statement of conservation goals.*

### Introduction

Since the fall of 1996, landowners have been compensated under the Continuous Enrollment Conservation Reserve Program for enrolling small acreages into selected conservation practices. These practices include filter strips, contour buffers, riparian (streamside) forest buffers, grassed waterways, field windbreaks, shelterbelts, living snow fences, shallow water areas for wildlife, crosswind trap strips, and wellhead protection areas (USDA 2000). The goals of the Continuous Enrollment Conservation Reserve



Savannah sparrow (K. Hollingsworth)

*... information on wildlife responses to Continuous Enrollment Conservation Reserve Program practices, especially filter strips and riparian forest buffers, is limited.*



Riparian forest buffer in Iowa (L. Betts)

Program are to protect soil, improve air and water quality, conserve biodiversity, beautify the landscape, and enhance fish and wildlife habitat. Eligible conservation practices, generally linear in configuration, are designed to buffer adjacent land uses, especially waterways, from the effects of agriculture. The U.S. Department of Agriculture has set a goal of establishing two million miles of conservation buffers by 2002. USDA incentives to encourage participation in the Buffers Initiative have been well received by landowners. In Iowa, for example, one in four landowners are presently participating in the Continuous Enrollment Conservation Reserve Program (Duane Miller, USDA Natural Resources Conservation Service, personal communication).

Except for grassed waterways, field windbreaks, and shelterbelts, information on wildlife responses to Continuous Enrollment Conservation Reserve Program practices, especially filter strips and riparian forest buffers, is limited. Consequently, the best indication that we have about how wildlife populations may be influenced by the Continuous Enrollment Conservation Reserve Program is provided by studies of other strip-cover habitats. In particular, bird communities have been studied in grassed waterways, herbaceous roadsides, and terraces associated with Midwest agricultural rowcrop fields. This report will focus on the findings of these and other related studies and their potential application to the establishment of conservation buffers.

### **Bird Species Composition and Abundance in Strip-cover Habitats**

Bird abundances in herbaceous strip-cover habitats are consistently higher than those in rowcrop fields (often by over an order of magnitude) and usually higher than those in other grassland block cover (Table 1). The difference between strip cover and block cover is even more pronounced relative to nest abundance (see Bird Nest Densities and Nesting Success in Strip-cover Habitats section). Among various strip-cover habitats, bird abundance and species composition differ and may be related to strip width (see Bird Response to Habitat Area and Strip Width section) and other management practices (see Vegetation Management section). Of the herbaceous strip-cover habitats studied (Table 1), grassed waterways attract the greatest variety of birds; 48 species have been recorded using waterways and 11 species are known to nest there. Not unexpectedly, bird abundance and species richness also have been reported to be greater in wooded strip-cover than in rowcrop fields (Gillespie et al. 1995). Furthermore, the presence of woody plants in strip-cover habitats increases the vertical structure and heterogeneity of the vegetation. This results in an increase in bird species diversity and abundance over what is found in herbaceous strip cover (e.g., Best 1983, Arnold 1983, Paruk 1990).

## Bird Nest Densities and Nesting Success in Strip-cover Habitats

Nest densities in herbaceous strip-cover are much greater than those in block cover with comparable vegetation. In some herbaceous strip-cover habitats in Iowa (e.g., grassed waterways and herbaceous roadsides) nest densities can exceed 1,000 nests/100 ha, densities far greater than what have been found in rowcrop fields or even CRP fields (Table 1). Furthermore, in other studies pheasant nest densities have consistently been documented to be higher in strip-cover habitats (e.g., fencerows, roadsides, drainage ditches) than in block-cover habitats (e.g., hayfields, small grains, pastures, wetlands) of the agricultural landscape (South Dakota, Trautman 1960; Wisconsin, Gates and Ostrom 1966; Minnesota, Chesness et al. 1968; Illinois, Warner et al. 1987). Higher nest densities in strip versus block cover also have been reported for wooded plant communities (Shalaway 1985).

Despite the high nest densities in strip-cover habitats, breeding productivity may be low. Studies have shown that nest failure rates may be higher in narrow strip-cover habitats than in block-cover habitats with comparable vegetation. This has been documented in both wooded (Vander Haegen and Degraaf 1996, Major et al. 1999) and grassed strip cover. In the Iowa studies, apparent nest success for grassed waterways, roadsides, and terraces was 15, 28, and 9%, respectively (Bryan and Best 1994, Camp and Best 1994, Hultquist 1999), compared with 38% in CRP fields with comparable plant cover (Patterson and Best 1996). In all cases the major cause of nest failure was predation, and predation was particularly intense in terraces, the narrowest of the strip-cover habitats evaluated (Fig. 1). Other studies have reported that, with the exception of crops subject to harvesting during the nesting season, nesting success for pheasants is lowest in herbaceous strip-cover habitats (Gates and Ostrom 1966, Chesness et al. 1968). Similarly, nesting success of waterfowl has been observed to be greater in blocks of upland habitat than in strip cover (Nelson and Duebbert 1973, Pasitschniak-Arts and Messier 1996).

Several explanations have been given for why predation rates may be elevated in strip-cover. These include: (1) predators may be more abundant in strip-cover habitats (Major et al. 1999), (2) predators may use strip cover as travel lanes (Fritzell 1978, Wegner and Merriam 1979), (3) predator search efficiency may be greater in strip cover because it has essentially a one-dimensional configuration (Major et al. 1999), and (4) predators may forage more intensively in areas with higher prey density (i.e., density-dependent predation) (Tinbergen et al. 1967, Gates and Gysel 1978, Warner et al. 1987, Sugden and Beyersbergen 1986, Martin 1988). Relative to the last mentioned explanation, cowbirds also may show a density-dependent functional response to potential hosts (Johnson and Temple 1990).

*Nest densities in herbaceous strip-cover are much greater than those in block cover with comparable vegetation. . . [but] nest failure rates may be higher in narrow strip-cover habitats than in block-cover habitats . . .*

Poor nesting success in strip-cover habitats has raised concern that in some instances they may function as ecological traps (Gates and Gysel 1978) in that they attract high densities of breeding birds but may provide suboptimal conditions for nesting success. The potential drawbacks of strip-cover habitats are often determined by how the strip cover is designed and managed (see Bird Response to Habitat Area and Strip Width and Management Considerations sections).

*Grassland birds respond strongly to structural features (height and density) of the vegetation, and each species has its own unique requirements.*

### **Bird Response to Vegetation Structure and Composition**

Grassland birds respond strongly to structural features (height and density) of the vegetation, and each species has its own unique requirements. The habitats preferred by grassland bird species range from low, sparse plant cover (e.g., horned lark, vesper sparrow) to tall, dense vegetation (e.g., sedge wren, Henslow's sparrow) (Skinner et al. 1984, Herkert et al. 1993, Swanson 1996, Sample and Mossman 1997). Accordingly, bird use of strip-cover habitats depends upon the structure of the vegetation (e.g., Camp and Best 1993, Bryan and Best 1994). Factors that influence vegetation structure include the plant species composition and various management practices such as mowing, grazing, and burning (Herkert et al. 1996).

In addition to structural features of the vegetation, birds respond to plant species composition (Skinner et al. 1984, Herkert et al. 1993, Swanson 1996, Sample and Mossman 1997). Of particular importance to grassland birds is the ratio of grasses to broad-leaved herbaceous plants (hereafter, forbs) and the presence of woody vegetation. The response of birds to the grass:forb ratio is well illustrated by the changes in bobolink and dickcissel abundances that parallel successional changes in hayfields and CRP fields. Over time, forb cover decreases and grass cover increases, with a concomitant decrease in dickcissel abundance and increase in bobolink numbers (Bollinger 1995, Patterson and Best 1996). Warner et al. (1987) reported that ring-necked pheasants prefer to nest in roadsides with a grass-legume mixture over those with only grass cover. Similar results have been reported for passerines (songbirds) (Paruk 1990, Warner 1992). The presence of woody vegetation, although attractive to woodland-edge birds, may adversely affect grassland species. This is illustrated by the propensity of some grassland birds (e.g., bobolinks, Henslow's and grasshopper sparrows) to avoid wooded edge habitats (Delisle and Savidge 1996, Helzer 1996, Winter et al. 2000). Lastly, bird habitat use may differ among grasslands composed of native versus introduced plant species (Delisle and Savidge 1997; McCoy et al., in press).

### **Bird Response to Habitat Area and Strip Width**

Several studies have documented a positive relationship between bird species richness (and probability of occurrence of certain species) and the size of grassland areas (hereafter, patch size) (Johnson and Temple 1986, Herkert 1994, Vickery et al. 1994, Swengel 1996, Helzer and Jelinski 1999, Renfrew

1999, Walk and Warner 1999). In particular, upland sandpipers, savannah sparrows, grasshopper sparrows, Henslow's sparrows, bobolinks, and eastern and western meadowlarks have been shown to be area sensitive (i.e., have minimum area requirements). In contrast, certain edge species commonly associated with grasslands (e.g., common yellowthroat, song sparrow, red-winged blackbird, American goldfinch) may be negatively affected by patch area. The occurrence of others (e.g., ring-necked pheasant, sedge wren) seemingly is not influenced by patch size.

Species sensitivity to grassland patch size may be manifest not only at the distributional level (i.e., presence-absence, relative abundance) but also relative to nesting success (demographic level) (Winter and Faaborg 1999). Studies have shown that nest predation rates for grassland birds are lower in large grassland patches compared with small ones (Johnson and Temple 1990, Greenwood et al. 1995, Winter et al. 2000).

For strip-cover habitats, a factor limiting bird use may not be area (strip-cover habitats can be many miles long) but rather the width of the habitat. Information on bird response to buffer width is better for woodland than for grassland communities. Researchers in a variety of locations have reported a positive relationship between the number of bird species (particularly Neotropical migrants) and the width of riparian forests (Stauffer and Best 1980, Keller et al. 1993, Dickson et al. 1995, Hodges and Krementz 1996, Kilgo et al. 1998). Limited information for grasslands can be gleaned from a few studies. Stauffer and Best (1980) reported a positive relationship between bird species richness and the width of herbaceous riparian habitats. When comparing interstate and secondary roadsides, Warner (1992) found that for passerines the nest densities and the number of nesting species increased with roadside width. In contrast, Carroll and Crawford (1991) reported that roadside width did not significantly influence nest-site selection by gray partridge. Renfrew (1999) documented occurrence and abundance of grassland birds in 10-m-wide filter strips and block-cover pastures and found the fewest species in the former. Bobolinks, eastern meadowlarks, and sedge wrens did not occur in the filter strips but were present in block-cover pastures.

Bird communities have been studied in three strip-cover habitats associated with Iowa rowcrop fields: terraces, herbaceous roadsides, and grassed waterways (Table 1). Although conducted in different years, these studies used similar research techniques. The predominant vegetation was smooth brome grass, and the three habitats represent a range of strip widths (Figure 1). A comparison among the three strip-cover habitats clearly shows that some bird species (e.g., bobolink, grasshopper sparrow, western meadowlark) do respond to strip width. This response may take the form of (1) increased abundance (or frequency of occurrence) with greater strip width or



Iowa filter strip (L. Betts)

***A comparison among . . . strip-cover habitats clearly shows that some bird species . . . do respond to strip width.***

(2) restriction of nesting to wider strips. Although the responses of individual bird species to strip width parallel what has already been documented for patch area (see Bird Response to Habitat Area and Strip Width section), a critical information void is the specific width requirements for area sensitive species. Managing the width of strip cover to reduce edge-related predation and brood parasitism (see Proximity to Woody Vegetation section) could enhance the suitability of these habitats for breeding birds.

### **Edge Aversion in Birds**

One factor contributing to habitat width sensitivity in birds is aversion to edges. Helzer and Jelinski (1999) found that the perimeter:area ratio of patches had more influence on the presence and richness of grassland bird species than did patch area, which suggests that proximity to edge may deter use of grasslands by some birds. By virtue of their design, strip-cover habitats have much greater perimeter:area ratios than block-cover habitats and, in the case of narrow strip cover, may consist entirely of edge. Studies have verified that some grassland bird species (e.g., grasshopper sparrow, bobolink, Henslow's sparrow, horned lark) either avoid nesting and(or) have reduced abundance near edges, particularly those that are wooded (Clark and Karr 1979, Johnson and Temple 1986, Delisle and Savidge 1996, Helzer 1996, Winter et al. 2000, O'Leary and Nyberg 2000).

### **Management Considerations**

#### **Vegetation Management**

*Controlled, periodic treatments  
(e.g., mowing, grazing, fire)  
to revitalize plant cover . . . can  
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both directly and indirectly.*

Controlled, periodic treatments (e.g., mowing, grazing, fire) to revitalize plant cover are necessary for the long-term maintenance of grassland habitats. These management approaches can influence bird communities both directly and indirectly. Mowing has two main effects on grassland birds: (1) it causes nest failure, loss of broods, and sometimes adult mortality, and (2) it alters the vertical structure of the vegetation. Inopportune mowing during the nesting season can have devastating effects on bird nesting success (e.g., Frawley 1989, Bollinger et al. 1990, Bryan and Best 1994). The frequency and extent to mowing determine the structure of the vegetation and, consequently, the composition of the bird community (see Bird Response to Vegetation Structure and Composition section). Furthermore, mowing causes site abandonment by some species, and recolonization may or may not take place depending upon the particular bird species and the degree of vegetative regrowth (Bollinger et al. 1990, Frawley and Best 1991). Mowing strip-cover habitats (e.g., grassed waterways) may be particularly problematic because these sites may represent renesting opportunities for birds that have experienced nest failure in hayfields earlier in the breeding season (Bryan and Best 1994).

Grazing can affect nesting birds indirectly by altering vegetation structure and directly through trampling or disturbing nest sites. The intensity and frequency of grazing determine the degree to which vegetation height is altered, and there is the potential, particularly for rotational grazing systems, of creating structural heterogeneity that may attract a wider variety of grassland bird species (Skinner et al. 1984). The likelihood that nests will be destroyed by trampling depends upon livestock density and duration of grazing (Jensen et al. 1990). Burning is frequently used to control woody plant encroachment in grasslands, and the denser regrowth of grassland vegetation after burning may reduce nest predation by restricting activity of nest predators and providing better nest concealment (Johnson and Temple 1990, Mankin and Warner 1992).

After initial seeding, vegetation in some grassland habitats (e.g., CRP fields, hayfields) undergoes successional changes in composition and structure unless the process is disrupted by land management practices. Over time, the forb component (including legumes) diminishes and grass cover increases (Basu et al. 1978, Bollinger 1995, Patterson and Best 1996, Millenbah et al. 1996). Also a litter layer develops over time (Millenbah et al. 1996) which creates a mechanical barrier to grass development and decreases the vigor of the grassland stand (Rice and Parenti 1978). These changes influence the composition of the avian community on such sites (see Bird Response to Vegetation Structure and Composition section). Warner et al. (1987) reported that late season mowing can enhance the competitive ability and, thus, longevity of legumes in a grass-forb planting.

### The Landscape Context

The value of grassland strip cover to birds may depend upon the landscape context (i.e., the surrounding land cover). Areas dominated by intensive rowcrop agriculture will differ from those with substantial amounts of pastureland, hayfields, and CRP fields. The availability of block-cover grassland habitats within the agricultural landscape can influence the occurrence and nesting success of birds in strip-cover habitats. For example, in Illinois pheasants were more likely to nest in roadsides when the roadsides were near other prime breeding habitats (hayfields, small grains) (Warner and Joselyn 1986, Warner et al. 1987). In contrast, densities of passerine nests in roadsides were highest where forage crops were relatively distant from roadsides and when small grain production was low regionally (Warner 1992). Warner (1994) also found that nest success of pheasants in strip cover was positively related to the amount of grass cover (including hay and small grains) in the landscape.



Contour buffers in Iowa (L. Betts)

*The value of grassland strip cover to birds may depend upon the landscape context (i.e., the surrounding land cover).*

*Presence of woody vegetation . . .  
in strip-cover habitats, such as filter  
strips and riparian buffers, may  
profoundly influence the habitat  
suitability for grassland birds.*

### **Proximity to Woody Vegetation**

Several studies of birds in grassland habitats have shown that rates of nest predation and brood parasitism by the brown-headed cowbird are higher near wooded edges (or trees) than farther away (i.e., nest success decreases closer to edges) (Best 1978, Gates and Gysel 1978, Moller 1989, Johnson and Temple 1986, 1990, Berg et al. 1992, Burger et al. 1994, Winter et al. 2000; but see Soderstrom et al. 1998). This may, in part, explain the avoidance of edges (or woody vegetation) by some grassland bird species (see Edge Aversion in Birds section). Cowbirds and avian predators use shrubs and trees as elevated perches from which to locate and monitor nests of potential hosts/prey (Payne 1973, Norman and Robertson 1975, Berg et al. 1992). Furthermore, the activity of potential nest predators may be greater near wooded edge habitats (e.g., Forsyth and Smith 1973, Bider 1968, Winter et al. 2000). Predation and parasitism rates are often significantly greater within 50 m of an edge (Paton 1994). Studies also have reported that proximity to wooded edges was more important than habitat patch size in determining grassland bird nest success (Burger et al. 1994, Winter et al. 2000). Presence of woody vegetation (either intentionally planted or resulting from encroachment) in strip-cover habitats, such as filter strips and riparian buffers, may profoundly influence the habitat suitability for grassland birds.

### **Sources or Sinks**

Bird populations in agricultural landscapes may consist of a network of source and sink subpopulations. The within-habitat reproduction in sink subpopulations is insufficient to balance local mortality, whereas the source subpopulations produce a surplus of individuals. Thus, the more productive source areas effectively subsidize or rescue unproductive sink areas (Pulliam 1988). There is an urgent need to identify and evaluate source and sink habitats (*a la* Donovan et al. 1995) within agroecosystems in order to provide meaningful recommendations for land-use practices and agricultural policy. Studies have shown that occurrence and density, when taken alone, may be misleading indicators of bird habitat quality and productivity (Van Horn 1983, Johnson and Temple 1986, Vickery et al. 1992). Although bird abundances and nest densities may be much higher in strip-cover than in block-cover habitats (see studies cited above), the high nest failure rates associated with many narrow, linear habitats may limit their value in bird conservation and management (Major et al. 1999). Some sources of nest failure, however, can be reduced through appropriate land-use decisions (e.g., deferred mowing, establishing minimum strip widths).

### **Setting Management Objectives**

The presence of shrubs and trees in strip-cover habitats increases bird abundance and species richness in agricultural landscapes (Best 1983, O'Conner 1984, Lack 1987, Paruk 1990). If the land-use objective is to enhance bird species diversity in intensively farmed areas, the establishment

and protection of woody plants in some strip cover is a reasonable management goal. On the other hand, if the objective is the conservation of grassland birds, maintaining woody vegetation in strip cover usually would be considered a liability (see Proximity to Woody Vegetation section, O'Leary and Nyberg 2000).

Because of their narrow, linear configuration, strip-cover habitats are better suited for generalist and/or edge species than for habitat interior and edge sensitive species. For species highly sensitive to habitat area or width, provisioning strip-cover habitats will do little for their conservation. Furthermore, although some grassland bird species of management concern (Sample and Mossman 1997) are present in strip-cover habitats, they compose a smaller proportion of the avian community in strip cover than in block-cover habitats. In the Iowa studies, for example, grassland birds of management concern composed 52% of the bird community in block-cover CRP fields but only 35, 19, and 38% of the avifauna in grassed waterways, herbaceous roadsides, and terraces, respectively (Table 1).

### The Relative Importance of Strip-cover Habitats

Strip-cover habitats constitute a significant proportion of the habitat available to birds in areas where agriculture is widespread and agricultural practices are intense (Williamson 1967, Warner 1994). One potential advantage of strip-cover habitats is that they are, or at least through appropriate management can be, free of some of the anthropogenic disturbances characteristic of cropland (cultivation, mowing, pesticide application, etc.). Furthermore, earliest nesting efforts by some grassland birds may not be directed at strip-cover habitats (Warner et al. 1987); thus, such habitats may serve as important renesting sites for birds that have experienced nest failure elsewhere (Bryan and Best 1994). For example, after hayfields are mowed, some birds resume breeding in other uncut cover (Albers 1978, Sample 1989, Bollinger et al. 1990, Igl 1991).

### Concluding Comments

Strip-cover habitats are not a panacea for birds in agricultural landscapes, but they can make an important contribution. The degree to which strip cover attracts various bird assemblages depends upon how it is designed and managed. Strip-cover habitats have the potential to greatly enrich the avifauna, particularly in areas subjected to intensive agriculture, and they are unrivaled in the bird densities they can contain. Whether these habitats serve as ecological traps or important production areas, however, will depend upon enlightened decisions in their placement, design, and management.



Dickcissel nest with four parasitic cowbird eggs (L. Best)

*Strip-cover habitats have the potential to greatly enrich the avifauna, particularly in areas subjected to intensive agriculture . . .*

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Table 1. Bird use of Iowa CRP fields, rowcrop fields, and strip-cover habitats associated with rowcrop fields during the summer breeding season. Except for fencerows, abundance values are expressed as birds observed/census count/100 ha. Values < 1 were excluded.

Bird Species	CRP Fields	Rowcrops	Fencerows					Grassed Terraces
			Herbaceous	Scattered Trees/Shrubs	Continuous Trees/Shrubs	Grassed Waterways	Herbaceous Roadsides	
Mallard			•					
Northern harrier*								
Red-tailed hawk						2	3	
American kestrel							2	
Northern bobwhite						1		4
Ring-necked pheasant	6•	2•	•			36•	8•	11•
Gray partridge						6	42•	
Killdeer	1	2•				19	1	1
Solitary sandpiper							1	
Upland sandpiper*	1•					5	2	4
Rock dove							1	
Mourning dove	1•	•	1	2	5•	14	7	4•
Yellow-billed cuckoo				1	3			
Black-billed cuckoo				4•	2			
Great horned owl						3		
Chimney swift								
Northern flicker				1	6•			
Red-bellied woodpecker				1				
Red-headed woodpecker				1	2		1	
Downy woodpecker					2			
Least flycatcher					4			
Eastern kingbird	1	1	4	2	5	6	18	1
Horned lark		12•	3			50	5	
Tree swallow						10		
Barn swallow	6	4		2		202	29	19
Cliff swallow						7		
Blue jay				1•	2			6
American crow		2			11	4	2	
Black-capped chickadee				2•	7	1		
Sedge wren*	3•					1•		2
Marsh wren							5	
House wren					4		1	
American robin		2		9•	7•	35	49	9•
Wood thrush						1		
Gray catbird				•	1•			
Brown thrasher				3•	1•	7	10	12
Loggerhead shrike*				2			2	
European starling					1•	22	3	
Common yellowthroat	11•	1	1		4	63•	4•	1
Wilson's warbler					1			
House sparrow				4	21	24	28	
Bobolink*	38•					7		
Eastern meadowlark*			1			2		
Western meadowlark*	6•	1				154•	99•	10
Red-winged blackbird	109•	20•	•	2•		513•	765•	173•
Brewer's blackbird*				18	7			
Common grackle	1	6		2	1	47	24	7

—Continued



**Table 1. Continued**—Bird use of Iowa CRP fields, rowcrop fields, and strip-cover habitats associated with rowcrop fields during the summer breeding season. Except for fencerows, abundance values are expressed as birds observed/census count/100 ha. Values < 1 were excluded.

Bird Species	CRP Fields	Rowcrops	Fencerows					
			Herbaceous	Scattered Trees/Shrubs	Continuous Trees/Shrubs	Grassed Waterways	Herbaceous Roadsides	Grassed Terraces
Brown-headed cowbird	10•	11•	35	18	25	117•	328•	17
Northern oriole					2	1		2
Northern cardinal				•	2•	1		
Rose-breasted grosbeak				1		1		
Indigo bunting			2		20	16	1	
Dickcissel*	58•	•	4	8	3	362•	52•	95•
American goldfinch	2•	1		5	4	25	10	2
Savannah sparrow*	8•					15	12	2
Grasshopper sparrow*	49•	1				106•	1	
Henslow's sparrow*								
Vesper sparrow*	1•	12•	24	8	8	126•	161•	46
Chipping sparrow					1		5	3
Field sparrow*						2•		13
Song sparrow	3•	1	•	4•	16•	95•	38•	9
Number of species	33	34	9	23	30	48	35	26
Total abundance	315	84	76	99	171	2198	1670	463
Number of nesting species	15	2-8	7	13		11	9	5
Nest density (#/100 ha)	263	15	—	—	—	1086	1176	648

**Sources of information:** **Rowcrop fields** (Patterson and Best 1996, unpubl. data); **CRP fields** (Patterson and Best 1996, unpubl. data); **Fencerows** (Best and Hill 1983, Best 1983), values expressed as birds/census count/10,000 m; **Waterways** (Bryan and Best 1991); **Roadsides** (Camp and Best 1993); and **Terraces** (Hultquist 1999).

• = Known to nest in that particular habitat. **References:** Shalaway (1985), Best (1986; only tilled fields), Bryan and Best 1994, Camp and Best (1994), Patterson and Best (1996), Hultquist (1999).

\* = Grassland bird species of management concern (Sample and Mossman 1997).

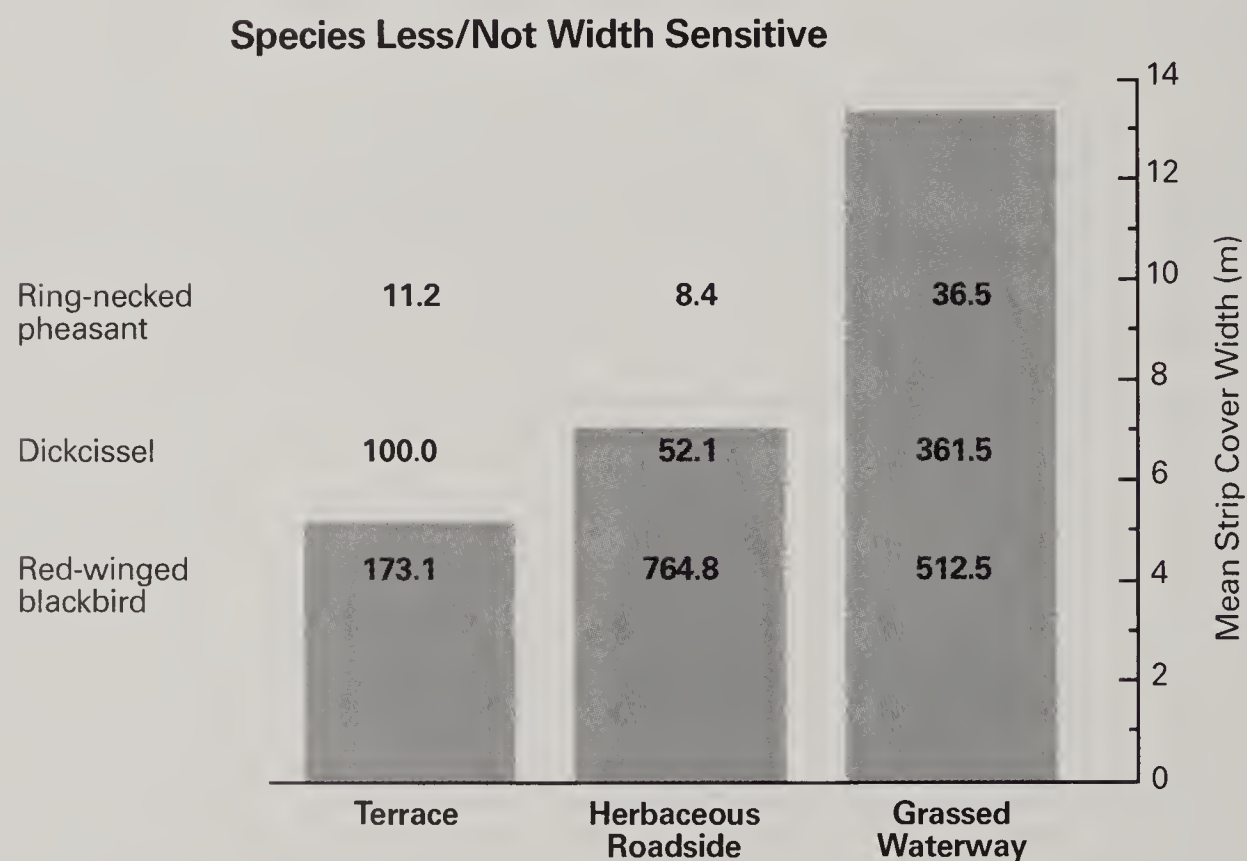
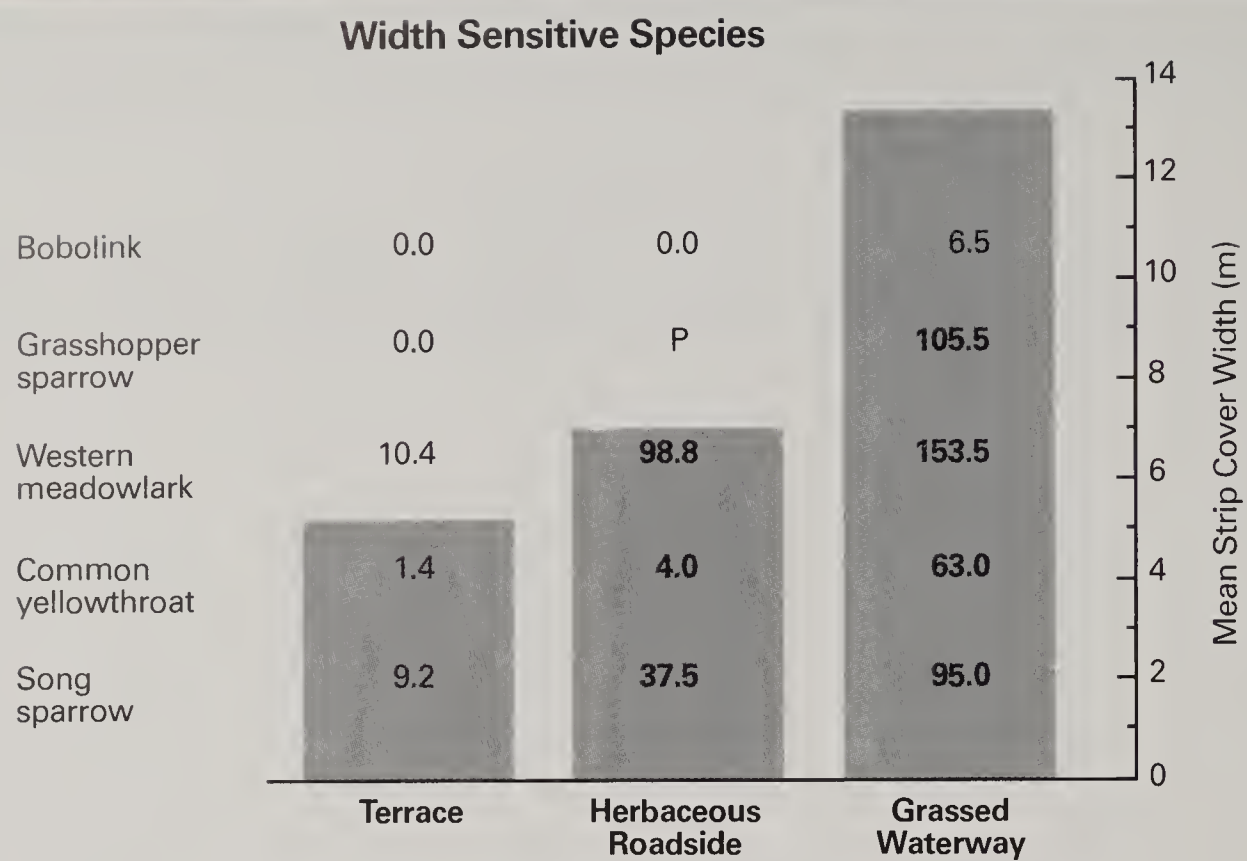


Figure 1. Abundance values (numbers/census count/100 m) for selected bird species in three strip-cover habitats in Iowa agricultural landscapes. Bold numbers indicate documented nesting. Histogram bars represent mean strip widths. References: Bryan and Best 1991, 1994; Camp and Best 1993, 1994; Hultquist 1999.

# Wetlands Reserve Program (WRP)

## Biological Responses to Wetland Restoration: Implications for Wildlife Habitat Development through the Wetlands Reserve Program

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WRP wetland in Iowa (L. Betts)

### Abstract

*The U.S. Department of Agriculture's Wetlands Reserve Program (WRP) provides incentives for landowners to restore function and value to degraded wetlands in agricultural landscapes. Since authorization of the program in the 1990 Farm Bill, landowner interest in WRP has resulted in enrollment of over 912,000 acres in permanent easements (76%), 30-year easements (18%), or 10-year cost-share agreements (6%). An additional 500,000 acres of unfunded projects have been offered for enrollment into the program. Current WRP enrollments consist of former bottomland hardwood wetlands and riparian floodplain habitats (55%), emergent wetland and open water complexes (15%), and nonwetland buffer areas (30%). In spite of the program's potential benefits for wildlife and popularity with landowners and conservation partners, few studies have been undertaken to evaluate wildlife responses to WRP. Therefore, to make inferences about WRP's effect on wildlife, I reviewed the general literature on wildlife responses to wetland restorations. My review supports the premise that potential benefits of WRP for wetland-associated wildlife are substantial, particularly in regions such as the Lower Mississippi Alluvial Valley and Central Valley of California where significant enrollments have occurred.*

### Introduction

Wetlands provide a variety of ecological, biological, and hydrologic functions that provide economic, aesthetic, recreational, educational, and other values to society (Mitsch and Gosselink 1986, National Research Council 1992, Heimlich et al. 1998). At the time Europeans arrived in North America, there were approximately 224 million acres of wetlands in the conterminous United States (Dahl 1990). By 1992, 45-50% of the original wetland area in this region had been converted to agricultural and other uses, with losses

approaching 90% in some states (Heinlich et al. 1998). The federal government played a significant role in the historic loss of wetlands through public works projects and assorted subsidies and incentives (U.S. Department of Interior 1988). In response to a growing understanding of and appreciation for wetland functions, federal wetlands policy and programs have shifted in recent decades toward providing protection for remaining wetlands and stimulating restoration of previously converted wetlands.

*Since 1992 the USDA Wetlands Reserve Program (WRP) has been a popular program for restoring degraded wetlands in agricultural landscapes.*

Since 1992 the USDA Wetlands Reserve Program (WRP) has been a popular program for restoring degraded wetlands in agricultural landscapes. The goal of WRP is to restore function and value to former or degraded wetlands. Conservation practices are undertaken on enrolled lands to restore hydrology, establish hydrophytic vegetation, and maximize wildlife habitat and other wetland functions in a cost-effective manner. Special emphasis is placed on benefits to migratory bird habitat through restoration and enhancement of site hydrology.

In spite of the program's potential benefits for wildlife, few studies have been undertaken to evaluate wildlife responses to WRP. However, wildlife assessments have been conducted on other wetland restoration and creation projects. These results can be used to make inferences about program benefits for wildlife in various regions in the United States. This paper provides a brief description of WRP, characterizes the types of habitats that are being established, summarizes the published literature on the biological responses to wetland restoration activities in general, and makes inferences about WRP benefits for wildlife.

## **Program Description**

The Wetlands Reserve Program was originally authorized in the 1990 Farm Bill and amended in the 1996 Farm Bill (16 U.S.C. 3837 et seq.). It is a voluntary wetland restoration program, where participating landowners establish conservation easements of either permanent or 30-year duration, or enter into restoration cost-share agreements where no easement is involved. In exchange for establishing permanent easements, landowners receive payments of up to the agricultural value of the land and 100% of the costs involved in restoring the wetlands. The 30-year easement payment is 75% of what would be provided for a permanent easement on the same site and 75% of the restoration cost. Cost-share agreements are for a minimum 10-year duration and provide for 75% of the cost of restoring the wetlands. Wetland protection and restoration are designated the primary land uses for the duration of easements and cost-share agreements. Landowners continue to control access to their land, and compatible uses of easement areas (e.g., timber harvest, grazing, etc.) may be authorized if they are determined by

USDA to be consistent with long-term wetland protection and enhancement goals. The program has a statutory enrollment cap of 975,000 acres.

## Program Delivery/Enrollment

Through June 2000, over 5,230 projects or 912,000 acres had been enrolled in permanent easements (76%), 30-year easements (18%), or 10-year cost-share agreements (6%). Projects range in size from two to 7,000 acres and average 175 acres. An additional 500,000 acres of unfunded projects have been offered for enrollment into the program. Clusters of individual projects are commonplace, especially in marginal flood-prone areas. Although projects are located in 47 states and Puerto Rico, the states with the most activity to date are Louisiana, Mississippi, Arkansas, California, Missouri, Iowa, Florida, Texas, Oklahoma, Illinois, and New York (Fig 1.).

A wide variety of freshwater wetlands in various geomorphological settings have been restored through the program. Once enrolled, wetlands are restored by physically manipulating the site to the extent necessary to restore hydrology, hydrophytic vegetation, and topographic surface features characteristic of natural wetlands. In large river floodplains that have been modified by construction of flood control levies, channelization, other large-scale drainage activities, and land leveling, this may involve constructing low-level levies to hold water on the restoration sites and excavation of shallow swales to mimic natural hydrologic conditions and surface features. Frequently, heavy-seeded tree species are planted to begin the process of restoring bottomland hardwood vegetation on these sites. In drained prairie potholes and other depressional wetlands, restoration of hydrology involves construction of earthen plugs on drainage ditches or breaking drainage tiles. A variety of water control structures are employed to provide management capabilities to many sites, enhancing their potential for management to maximize wildlife habitat functions.

The program has been embraced by wildlife managers as a critical tool for meeting wetland habitat goals on private lands. For example, in the Lower Mississippi Alluvial Valley, WRP is seen as the major avenue to accomplishing the 521,000-acre bottomland hardwood wetland habitat restoration objective set by the North American Waterfowl Management Plan's Lower Mississippi Valley Joint Venture (Baxter et al. 1996). WRP also is being employed to meet wildlife habitat objectives in the Central Valley of California, Prairie Pothole Region, and other parts of the country that have experienced substantial wetland habitat losses. Due to the program's potential to provide significant habitat accomplishments, diverse partnerships have formed to assist in program delivery. The U.S. Fish and Wildlife Service, U.S. Forest Service, Ducks Unlimited, state fish and wildlife agencies, water-

*Through June 2000, over 5,230 projects or 912,000 acres had been enrolled in permanent easements (76%), 30-year easements (18%), or 10-year cost-share agreements (6%).*

fowl associations, and a variety of other entities are heavily engaged in various aspects of WRP implementation in the field.

Due to the short time the program has been operational, most wetlands enrolled have been restored only within the past few years and are in the early stage of vegetation development. Habitat types being targeted by WRP are bottomland hardwood forest, emergent marsh/open water wetlands, western riparian wetlands, and nonwetland buffer areas.

### **Bottomland Hardwood Forest**

*Approximately 50% of all lands currently enrolled in WRP consist of former bottomland hardwood forests . . .*

Approximately 50% of all lands currently enrolled in WRP consist of former bottomland hardwood forests that have been used for agriculture. These occur primarily in large river floodplain bottomlands of the lower Mississippi River and its tributaries and other river systems of the south and east. Restoration activities typically involve restoring hydrology and planting three to seven species of bottomland hardwood trees. Table 1 provides an example of one state's list of tree species planted on bottomland hardwood restoration sites. Tree species planted are intended to eventually become dominant in the bottomland hardwood forest overstory. While many WRP bottomland hardwood restoration sites have developed emergent vegetation, over time it is projected that diverse forested wetland communities will develop.

In many instances, existing drainage and levy systems prevent fully restoring floodplain hydrology to WRP sites (King and Keeland 1999). Therefore, smaller levies, ditch plugs, and water control structures are constructed on-site to mimic surrounding natural hydrologic conditions to the extent feasible. In addition, since many WRP restoration sites have been conditioned through precision land leveling and farming activities, swales, small pits, and other surface features may be excavated to recontour the surface, providing a range of soil moisture conditions and local habitat features.

### **Emergent Marsh and Open Water**

Approximately 15% of the area enrolled in WRP consists of emergent wetland and open water complexes. Some of these areas occur on small portions of bottomland hardwood contracts that are expected to remain in open water or herbaceous vegetation, but most occur in prairie grassland settings, marshlands of California's Central Valley, and other nonforested landscapes. Restoration is generally accomplished by breaking drainage tiles, installing ditch plugs, and constructing low-level earthen berms to restore wetland hydrology. In areas that have been land-leveled to facilitate production of rice and other crops, shallow swales may be excavated to reestablish more natural surface topography and provide areas with more permanent hydroperiod. Herbaceous wetland vegetation is established primarily through natural colonization and germination of wetland plant seeds stored in the soil seedbank.

### Riparian Wetlands

Riparian wetland restoration comprises approximately 5% of the acres enrolled in WRP. These areas are primarily associated with river systems in the western United States. Riparian vegetation is reestablished on these sites primarily through natural regeneration and control of salt cedar and other exotic species.

### Nonwetland Buffer

Approximately 30% of acres enrolled consist of nonwetland buffer areas. The amount of upland buffer included in WRP contracts varies widely among regions and individual enrollments. For example, an enrollment containing a complex of prairie pothole wetlands may include a significant amount of upland grassland useful as dense nesting cover for waterfowl and other wildlife. However, an enrollment on a large river floodplain may consist entirely of wetland to be restored. Program policy dictates that no more than 50% of an individual enrollment consist of nonwetland area. However, this requirement may be waived in cases where important wetland complexes are enrolled.

### Biological Responses to Restored Wetland Habitats

Below is a summary of published information on biological responses to wetland restoration and creation efforts by wetland type.

#### Bottomland Hardwood Forest and Riparian Wetlands

Much attention has been given in recent years to the effectiveness of restoring bottomland hardwood wetland systems in the Southeast (Newling 1990). Much of the work done has focused on the challenge of establishing wetland hydrology in light of large-scale hydrologic alterations and social conditions, and establishing diverse stands of bottomland hardwood tree species. Reforestation efforts are based on silvicultural principles (see Fowells 1965), planting bottomland hardwood forest overstory trees and natural regeneration of vegetation on the site. Local problems, such as drought, herbivory, and flooding, can limit success (King and Keeland 1999).

The majority of bottomland hardwood wetlands restored through WRP are former agricultural fields. For all practical purposes, it will be some time before these areas begin to resemble the forested wetland communities that formerly characterized the region. In the meantime, these areas provide wetland functions and habitats similar to those provided by emergent wetlands. For purposes of this assessment, documented biological response to emergent wetland restoration and establishment actions will be assumed to also apply to these early developmental stages of bottomland hardwood restoration projects. In addition, the following observations can be made that apply to recently restored bottomland hardwood wetlands.

*Much attention has been given in recent years to the effectiveness of restoring bottomland hardwood wetland systems in the Southeast . . .*

## Vegetation

Tree seedling survival is an important aspect of determining success of bottomland hardwood restoration (Allen and Kennedy 1989). Seedling growth and survival varies by species and site condition (Teskey and Hinckley 1977). Wallace et al. (1996) found that planted red maple, pop ash, pond pine, pond cypress, and bald cypress seedlings can reasonably be expected to survive at least one year under a broad range of hydrological and soil conditions. Competition with herbaceous vegetation is an important factor, but tree seedling planting site elevation and associated soil moisture and flooding has been shown to be more important for seedling growth and survival than control of herbaceous vegetation competition (McLeod et al. 2000). Thus, establishment of appropriate hydroperiods and site topography provides a variety of planting elevations and helps ensure greater probability of planted tree seedling growth and survival (Barry et al. 1996, Deitz et al. 1996, King and Keeland 1999).

## Birds

### ***Bird communities in restored bottomland hardwood forests change over time in response to development of vegetative structure . . .***

Bird communities in restored bottomland hardwood forests change over time in response to development of vegetative structure (Nuttall and Burger 1996, Twedt and Portwood 1997). While total bird abundance may remain relatively constant through time, species richness has been shown to increase with stand age (Nuttall and Burger 1996). As the forested community matures, the bird community shifts from grassland species to forest dwelling species (Wilson and Twedt, in press). Management prescriptions that mimic natural succession such as mixed plantings or thinning are believed to promote early colonization by birds associated with mature forests (Nuttall and Burger 1996).

Twedt and Uihlein (in press) developed a method for geographically prioritizing reforestation efforts in the Lower Mississippi Alluvial Valley based on habitat needs of forest breeding landbirds. They found that Bird Conservation Regions identified in Partners in Flight's Bird Conservation Plan for the Lower Mississippi Alluvial Valley encompassed approximately 70% of the area identified by the method as high priority for reforestation. They also found that lands enrolled in WRP in the region contain a high proportion of lands with high reforestation priority, indicating the potential for WRP reforestation sites to benefit forest breeding land birds. However, Wilson and Twedt (in press) found that forest landbirds did not colonize bottomland hardwood forest plantings until 15 years after planting. They recommend planting some fast-growing tree species to provide vertical structure more quickly to benefit forest birds earlier. However, other wildlife species benefit from the emergent wetlands associated with early successional stages of forested wetland restoration efforts. Bird communities of these recently restored sites are frequently similar to that of comparable natural herbaceous wetlands (Brown and Smith 1998).

Horizontal and vertical foliage diversity in riparian floodplain areas are positively correlated with the number of bird species using an area (Anderson et al. 1979). In riparian areas along the lower Colorado River, Anderson and Ohmart (1984) found that vegetation growth and avian colonization occurred rapidly after restoration. Cottonwood, willow, and quail bush were associated with increased avian use. Elimination of exotic salt cedar and leaving native vegetation also enhanced avian use of riparian areas.

In some situations, forested wetlands have been impacted by drainage but not cleared. Although the forest vegetation remains, wetland functions are reduced or eliminated due to lack of wetland hydrology and changes in vegetation species composition in response to altered water regimes. Wetland functions may be recovered in these areas by returning the wetland hydrology and other management actions. Weller (1995) found that wetland habitat functions returned to a drained south Florida wetland within three years of reestablishing wetland hydrology and removal of exotic Brazilian pepper (*Schinus terebinthifolius*) vegetation. The restoration action resulted in the return of 16 wetland bird species, eight fish species, six species of turtles, six species of snails, two frog species, and the American alligator (*Alligator mississippiensis*).

## Freshwater Emergent Wetlands

### Vegetation

In most situations, wetland vegetation quickly colonizes restored wetlands on abandoned agricultural fields following the return of wetland hydrology (LaGrange and Dinsmore 1989, Anderson 1991, Sewell and Higgins 1991, Galatowitsch and van der Valk 1996a, Brown 1999). Reaves and Croteau-Hartman's (1994) review of the published literature indicated that native aquatic plants generally return to restored wetlands within one year following restoration of wetland hydrology. LaGrange and Dinsmore (1989) found a total of 45 plant species in four formerly restored wetlands several years after they were reflooded.

Size of restored basins influences rate of revegetation. Guggisberg (1996) found that cattails quickly colonized smaller restored herbaceous wetlands in Wisconsin, while larger basins developed greater vegetation diversity. Brown (1999) found that plant communities at restored wetland sites in New York became increasingly similar to those of natural wetlands over time.

Rapid colonization of wetland vegetation primarily is due to germination of seeds persisting in drained wetland soils after wetland hydrology has been restored (Weinhold and van der Valk 1989) or dispersal from other areas. Though natural wetland plant colonization typically is rapid, introduction of wetland soils from other sites may augment natural regeneration of wetland



Aquatic plants return one year after restoration. (C. Rewa)

*In most situations, wetland vegetation quickly colonizes restored wetlands on abandoned agricultural fields following the return of wetland hydrology . . .*

plants (Brown et al. 1997). Trees and shrubs from adjacent sites also have been successfully transplanted to restored wetlands using construction equipment while restoration work is being conducted (Lehman et al. 1999).

Basin morphology also plays a role in wetland vegetation response (Rossiter and Crawford 1986). Galatowitsch and van der Valk (1996a) studied basin characteristics of 62 recently restored prairie wetlands in Iowa, Minnesota, and South Dakota. Most restored wetlands had basin morphologies comparable to natural wetlands, met or exceeded predicted hydrology, and had developed emergent and submersed aquatic vegetation zones. However, only a few basins developed wet prairie and sedge meadow zones.

The method of drainage also affects how quickly wetland vegetation returns and initial species composition. Galatowitsch and van der Valk (1993) found that tile-drained wetlands had fewer wetland plants than ditch-drained wetlands due to thoroughness of drainage and lack of refugia for wetland plants. Regardless of drainage history, they found that recently restored prairie wetlands lacked the perimeter zones of wet prairie and sedge meadow vegetation. Whereas many submersed aquatic plants are able to colonize restored basins rapidly, some emergent and wet meadow species may take longer to become established. Galatowitsch and van der Valk (1996b) found that three-year-old restored prairie wetlands in Iowa had more species of submerged aquatic plants after reflooding than did natural wetlands.

#### *Invertebrates*

Restored wetlands may be quickly colonized by a variety of aquatic invertebrates and other animals (Reaves and Croteau-Hartman 1994). Brown et al. (1997) found similar invertebrate taxa between natural wetlands and restored wetlands in New York. Insects with aerial dispersal colonized restored wetlands more rapidly than less mobile invertebrates. Surface mine sediment ponds were colonized by 66 invertebrate taxa in the first year and 44 invertebrate taxa second year after construction (Fowler et al. 1985).

***The invertebrate fauna  
of restored wetlands  
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vegetation structure . . .***

The invertebrate fauna of restored wetlands resembles that of natural wetlands with similar vegetation structure (Brown et al. 1997). Mayer and Galatowitsch (1999) found diatom species richness and composition in restored prairie wetlands in North Dakota to be similar to that of natural wetlands. LaGrange and Dinsmore (1989) found a total of 18 wetland invertebrate species in four restored prairie wetlands several years after they were reflooded. In a survey of 156 restored seasonal and semipermanent wetlands in Minnesota and South Dakota, Sewell and Higgins (1991) found 31 taxa of aquatic macroinvertebrates in restored wetlands, 12 of which occurred in the first year following restoration.

Benthic invertebrate communities are strongly associated with wetland vegetation (Streever et al. 1995). In a created freshwater wetland in central Florida, Streever et al. (1995) found three of five common chironomid genera were more abundant in areas with greater than 50% herbaceous cover than more open areas; abundance of five common genera was greatest in areas with > 80% vegetative cover. Transplantation of remnant wetland soil that increases the rate of wetland plant establishment also can increase overall invertebrate abundance in restored wetlands (Brown et al. 1997).

Invertebrate taxa used to assess biotic response to restored wetlands vary temporally and spatially (Brown et al. 1997). Ettema et al. (1998) found spatial distribution within a restored wetland in Georgia varied substantially among nematode taxa, with substantial temporal variation within taxa. Distribution of nematode taxa did not correlate well with soil resource patterns. In a rehabilitated wetland in northern Spain, Valladares Diez et al. (1994) found that a diverse community of Coleoptera had developed, but most species found belong to early successional groups or are ubiquitists. In the same restored wetland, Gonzales Martinez and Valladares Diez (1996) found aquatic Heteroptera and Odonata communities to be similar to natural immature wetlands (ubiquitists and pioneers). In general, the communities of beetles, dragonflies, and aquatic heteropterans are representative of recent wetlands, with evidence of changes toward a more stable and mature environment.

#### *Reptiles and Amphibians*

Several studies illustrate rapid amphibian colonization of constructed and restored wetlands. Fowler et al. (1985) documented 12 species of breeding amphibians in surface mine sediment ponds constructed in western Tennessee; all ponds surveyed contained at least one breeding amphibian species. Anderson (1991) found American toads (*Bufo americanus*), green frogs (*Rana clamitans*), and leopard frogs (*Rana pipiens*) using recently restored wetlands in Wisconsin. Lacki et al. (1992) found that a wetland constructed for treatment of mine water drainage in east central Ohio supported greater abundance and species richness of herpetofauna than surrounding natural wetlands. This was primarily due to the large number of green frogs and pickerel frogs and numerous species of snakes found using this site.

Landscape condition and surrounding land use are critical components that influence amphibian use of restored wetlands. In glacial marshes in Minnesota, Lehtinen et al. (1999) found amphibian species richness was lower with greater wetland isolation and road density at all spatial scales in both tallgrass prairie and northern hardwood forest ecoregions. Likewise, elimination of small wetlands that are relied upon by reptiles and amphibians can have a devastating effect on habitat availability and populations of these animals (Gibbs 1993).

***Landscape condition and surrounding land use are critical components that influence amphibian use of restored wetlands.***

## Birds

Numerous studies have documented extensive bird use of restored freshwater wetlands. LaGrange and Dinsmore (1989) found a total of 11 bird species in four formerly drained prairie wetland basins several years after the basins were reflooded. Anderson (1991) monitored wildlife use of small restored wetlands in Wisconsin and documented use by nesting ducks, marsh wrens, sandpipers, and woodcock. Although no quantitative data were collected, Oertel (1997) noted substantial increases in wetland-associated wildlife use following restoration of a 55-acre wetland in northern New York. Dick (1993) observed wetland-dependent birds using an 80-acre restored wetland site in south central Pennsylvania during the first year after restoration. Bird groups observed included winter raptors, wintering and migrating ducks, geese and tundra swans, foraging wading birds, waterfowl and shorebirds, and other birds. Breeding mallards, wood ducks, sora rails, sedge wrens, common snipes, spotted sandpipers and pied-billed grebes were documented. Restoration of the wetland increased bird diversity by 60% during the first year.

In most situations, birds rapidly colonized restored wetlands, usually in the first year after restoration. Delehanty and Svedarsky (1993) found breeding black terns using a restored prairie wetland during the second and third breeding seasons after restoration. As many as 40 adults were present in the marsh during the third breeding season, and a minimum of seven young were fledged. Sewell and Higgins (1991) found 12 species of waterfowl using restored wetlands of varying ages in Minnesota and South Dakota. During the first five years after restoration, White and Bayley (1999) documented 50 shorebird species, 44 waterfowl species, 15 raptor species, and 28 other new bird species using a 1,246-ha northern prairie wetland that was restored and flooded with municipal wastewater. These studies clearly show how quickly wetland-associated birds respond to restored wetland habitats.

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Bird use generally increases with the size of restored wetlands. Brown and Dinsmore (1986) found more diverse bird communities in larger prairie marshes. Among restored emergent wetlands in Wisconsin, Guggisberg (1996) found that large restored wetlands had greater nongame bird species richness than did small wetlands. In restored herbaceous wetlands in northern Iowa, Hemesath and Dinsmore (1993) found that breeding bird species richness increased with wetland size, regardless of the age of the wetlands or duration of drainage. However, plant succession influences bird use of restored basins (Wilson and Twedt, in press). Vanrees-Siewert and Dinsmore (1996) found that total bird species richness increased with age of restored prairie wetlands in Iowa, while waterfowl use (breeding and total) was influenced by restored wetland size, regardless of age.

Habitat structure in restored wetlands appears to be the primary element that determines bird use. Density of waterfowl breeding pairs was lower in borrow ponds constructed along a highway in North Dakota than in natural basins of similar size (Rossiter and Crawford 1981, 1986). This was attributed to lack of shallow water area and emergent wetland vegetation in borrow area wetlands. During drought conditions, Ruwaldt et al. (1979) found spring waterfowl pair use in South Dakota was greater in semipermanent natural wetlands and artificial stock ponds than in other wetland types, indicating the importance of surface water availability to breeding waterfowl.

Bird use of restored wetland systems has been shown to be similar to that of natural wetlands with similar habitat structure (Brown and Smith 1998). Brown and Smith (1998) found that the number of bird species and bird abundance did not differ between restored and natural wetlands in New York for the three bird groups studied (wetland-dependent, wetland-associated, and nonwetland birds). They found bird communities were more similar among restored sites than between restored and natural wetland sites. Delphey and Dinsmore (1993) found species richness of breeding birds was higher at natural wetlands than restored prairie wetlands. However, duck species richness and pair counts did not differ between natural and restored wetlands. Drought during the study may have influenced results.

Brown (1999) found more wildlife plant foods and greater coverage of these plant species in restored wetlands than in natural wetlands in New York. Differences in bird similarity between natural and restored wetlands may disappear as restored wetlands develop over time (Brown and Smith 1998).

Bird use also is influenced by characteristics of wetland complexes and adjacent land uses (e.g., Reaves and Croteau-Hartman 1994). Whereas local wetland features dictate suitability for less mobile wetland bird species, wide-ranging species are greatly affected by the characteristics of the surrounding landscape. For example, Naugle et al. (1999) found that while pied-billed grebes and yellow-headed blackbirds used wetlands in South Dakota based on site conditions, use of wetlands by black terns, a wide-ranging species, was dictated more by surrounding land uses. Fairbairn (1999) found bird diversity within wetland complexes to be positively associated with the percentage of wetland area with emergent vegetation, total wetland area within 3 km, and total area of semipermanent wetlands. Naugle et al. (2000) found black tern use of prairie wetlands was correlated with wetland area, amount of semipermanent wetland area within the wetland, and grassland area in the surrounding landscape. Black tern use was associated with large wetland basins located in high-density wetland complexes, illustrating the importance of considering entire landscapes in habitat assessments and conservation efforts.



Mallard hen and brood (C. Schwartz)

*Bird use . . . is influenced  
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## Landscape Effects

As previously indicated, surrounding land use can affect wildlife use of restored wetlands (Wilson and Mitsch 1996, Naugle et al. 1999). Lehtinen et al. (1999) suggest that regional wetland conservation strategies should include reversing trends in habitat fragmentation. Effective regional strategies must include restoration of a diversity of wetland types, including small and rarer wetland types as well as historically more extensive wetland systems (Gibbs 1993, Detenbeck et al. 1999), and providing adequate upland buffers around wetlands and within wetland complexes.

Provision of wetland complexes, vegetative diversity, interspersions of water and vegetation, and wetland configuration and edge were identified as important factors influencing waterfowl habitat potential (Weller 1990). In studying characteristics of restored prairie wetlands, Galatowitsch and van der Valk (1996a) argued that success of restoration efforts was limited by the number of wetland basins affected (i.e., scale). They recommended that emphasis should be placed on restoring complexes of wetlands representing a variety of wetland classes and sizes. To address this issue, Galatowitsch et al. (1998) suggested using a planning framework for restoration of prairie wetlands that focuses on restoring wetland complexes rather than on isolated wetland basins, and that restoration expectations based on this concept should be used in evaluating success of prairie wetland restoration efforts. Similarly, Bedford (1999) suggested that, to increase the chances of providing wetland functions on the landscape, an analysis of cumulative wetland impacts in regional wetland restoration planning should be undertaken.

Although careful planning is important, it is difficult to precisely predict vegetation and wildlife response to created or restored wetlands (Malakoff 1998). Additional time and allowance for natural processes to shape the wetland should be considered in implementing wetland establishment projects. Specifically, adaptive management and corrective measures should guide the restoration process through time (Weinstein et al. 1997). Complete restoration of wetland functions may require 15 to 20 years (Mitsch and Wilson 1996).

### *Monitoring progress of restored wetland systems is important . . .*

Monitoring progress of restored wetland systems is important (Metzker and Mitsch 1997). Until recently, very little effort has been placed on short-term or long-term monitoring of restored wetlands (Lewis et al. 1994). Monitoring to compare restored wetlands to natural wetlands over time regarding rates of revegetation, use by animal species, development of soil profiles and patterns of vegetation change is needed (Lewis et al. 1994).

When planting vegetation is necessary, native plant materials from local genetic stocks should be used to maximize success and avoid impacts to native flora and fauna in the area (Padgett and Crow 1994). Monitoring

development of restored wetlands allows wetland managers to identify and possibly prevent problems associated with invasive species and other management challenges.

Wetland restoration and creation is an evolving discipline (Zedler 1987). Young (1996) pointed out the complexity of creating wetland systems and the importance of establishing wetland hydrology in wetland construction work. While the focus of wetland restoration work is largely on restoring wetland hydrology and vegetation, restoration work should be multidisciplinary, integrating water quality, wildlife habitat, flood abatement, and other benefits (Almendinger 1998, Montgomery 2000).

## Wildlife Benefits of WRP

Over 915,000 acres are currently enrolled in WRP, mostly in permanent easements. While actual wildlife use of these lands has not been determined, the literature on wildlife use of other restored wetlands suggests that many species likely are benefiting from the habitats being created through this program. The lack of information prevents us from making definitive statements about wildlife benefits of the program. Nonetheless, the extent and variety of wetland habitats being created, and similarity of WRP areas to other wetland restorations, supports the premise that potential benefits of WRP for wetland-associated wildlife are substantial.

For example, in the Southeast, bottomland hardwood forests restored under WRP are contributing significantly to reaching regional habitat goals of the North American Waterfowl Management Plan (Baxter et al. 1996). Although many of these wetlands presently are vegetated with early successional plants, they eventually will develop into bottomland hardwood forests. Additionally, since many WRP sites in the Lower Mississippi Alluvial Valley occur in high priority bird conservation areas (Twedt and Uihlein, in press), it is probable that they will play an increasingly important role in the conservation of migratory landbirds, as well as waterfowl.

Similarly, the literature suggests that most restored emergent wetlands are quickly vegetated and colonized by a variety of wetland wildlife species (Anderson and Ohmart 1984, Anderson 1991, Sewell and Higgins 1991, Dick 1993, Brown and Smith 1998). In the Prairie Pothole Region of the Dakotas, Minnesota, and Iowa, where creation of wetland complexes is of particular importance for breeding waterfowl and other wildlife, WRP and other wetland restoration efforts will play a critical role in achieving bird conservation objectives (Delehanty and Svedarsky 1993, Delphey and Dinsmore 1993, Galatowitsch et al. 1998, Fairbairn 1999). The upland areas established within WRP land enrollments provide upland nesting cover for



Waterfowl in WRP wetland (C. Schwartz)

*... the extent and variety of wetland habitats being created, and similarity of WRP areas to other wetland restorations, supports the premise that potential benefits of WRP for wetland-associated wildlife are substantial.*

waterfowl and other wildlife, and also serve to protect restored wetlands from siltation and other impacts associated with adjacent land use (see Naugle et al. 2000).

*Additional monitoring is needed to gain a better understanding of wildlife responses to management and program benefits for wildlife.*

It is difficult to quantify the contributions that WRP wetlands currently are making to wildlife conservation. However, the wetland restoration literature strongly suggests that wildlife benefits are realized quickly when formerly drained or degraded wetlands are restored. Additional monitoring is needed to gain a better understanding of wildlife responses to management and program benefits for wildlife.

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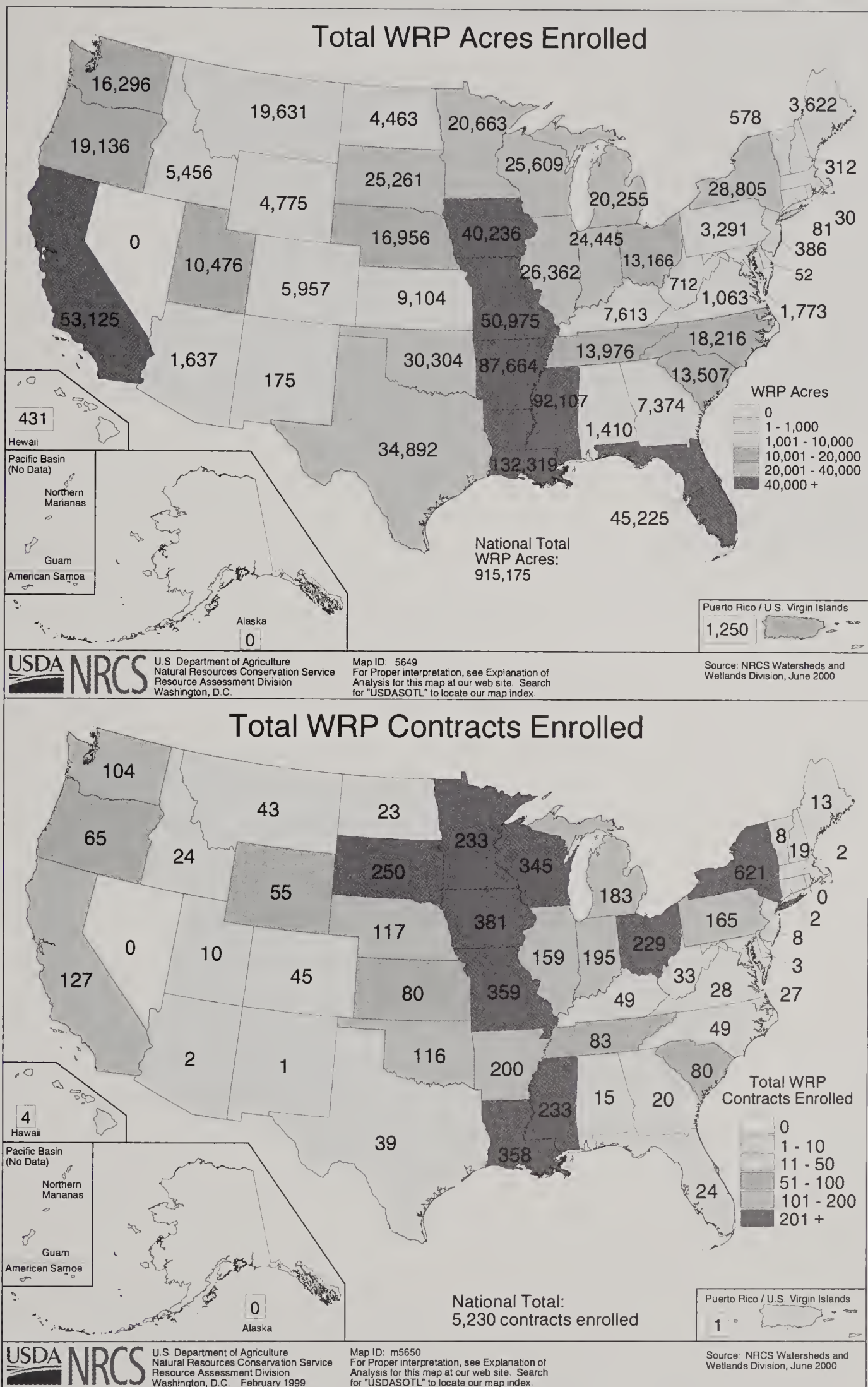


Figure 1. Wetlands Reserve Program (WRP) enrollment through June 2000 (<http://www.wl.fb-net.org/temp.htm>).

**Table 1. Approved bottomland hardwood tree species for WRP in Mississippi.**

Bald cypress	Swamp chestnut oak
Bitter pecan	Cottonwood
Green ash	Sweetgum
Overcup oak	Sycamore
Nuttal oak	Hackberry
Cherrybark oak	Persimmon
Swamp white oak	Red maple
Southern red oak	Pecan
Water oak	American elm
Willow oak	Cedar elm
Shumard oak	Water tupelo

Tree species planted is a function of site condition (hydrology and availability of adjacent seed source) and seedling availability.

# The Wildlife Habitat Incentives Program

## A Summary of Accomplishments 1998–1999

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### Abstract

*The Wildlife Habitat Incentives Program (WHIP) is one of a suite of conservation provisions added to the amended 1985 Food Security Act in 1996. WHIP was developed to assist landowners with habitat restoration and management activities specifically targeting fish and wildlife, including threatened and endangered species. Within the framework of state, regional, and national habitat priorities, WHIP funds were allocated to states based on plans developed by state conservationists in consultation with their state technical committees. Special consideration was given to locally led initiatives with substantial outside funding and partnership participation. Of the \$50 million available for WHIP in 1998 or 1999, \$30 million was distributed to states for financial and technical assistance in 1998 and \$20 million in 1999. These distributions resulted in 4,600 projects affecting 672,000 acres in 1998 and 3,855 projects on 721,249 acres in 1999. WHIP projects averaged 146 (1998) or 187 (1999) acres in size and \$4,600 in cost-share. WHIP targeted a wide range of fish and wildlife species, from economically and culturally important species such as northern bobwhite quail and Atlantic salmon to threatened and endangered species such as Karner blue butterfly and Indiana bat. WHIP also provided cost-share for restoration of critical aquatic habitat such as cold water streams and rare terrestrial habitats in oak savanna, longleaf pine, prairie, and riparian ecosystems. WHIP was extremely popular with landowners and conservation partners because it targeted wildlife and addressed important management needs identified at the local level that were not eligible for cost-share under other USDA conservation programs.*

### Introduction

The Wildlife Habitat Incentives Program (WHIP) is one of a suite of conservation provisions added to the amended 1985 Food Security Act in 1996.

Administered by the Natural Resources Conservation Service (NRCS), WHIP is a voluntary program that was established to improve wildlife habitat in our nation by providing financial and technical assistance to landowners wanting



Wisconsin stream restoration  
(W. Hohman)

*WHIP was extremely popular with landowners and conservation partners because it targeted wildlife and addressed important management needs identified at the local level . . .*

to develop upland, wetland, threatened and endangered species, fish and other types of wildlife habitat (Federal Register 1997). In this chapter, I further describe WHIP and summarize accomplishments for 1998 and 1999.

### **Program Priorities Were Established at the State Level**

Within the framework of regional and national habitat priorities, WHIP priorities were identified in plans developed by state conservationists in consultation with state technical committees comprised NRCS state staff, representatives from other government agencies and nongovernmental organizations, and landowners. Wildlife management needs identified by conservation groups before passage of the 1996 Farm Bill (e.g., Wildlife Management Institute publication, *How much is enough?*) also influenced the establishment of WHIP priorities (McKenzie and Riley 1995, National Audubon Society 1995). Flexibility in the establishment of WHIP priorities allowed states to address a wide assortment of wildlife needs across the United States and resulted in what appeared to be 51 independent programs. This diversity, however, is considered a strength of the program (Federal Register 1997, Burke 1999, Zinn 2000).

### **A Wide Range of Activities Were Initiated under WHIP**

WHIP priorities identified by the states were summarized somewhat differently by Burke (1999) and NRCS (1999). Burke (1999) summarized WHIP priorities in terms of three general categories: (1) rare, declining, threatened, or endangered species; (2) economic wildlife issues; and (3) native habitats (Burke 1999). These categories were not mutually exclusive. For instance, proposed work on a native plant communities in longleaf pine ecosystem also was recorded as applying to economically important and threatened and endangered species (e.g., northern bobwhite quail and red-cockaded woodpecker, respectively). Burke's (1999) breakdown of WHIP priorities indicated that state plans focused on restoration of native habitats with equal emphasis given to economic wildlife and threatened and endangered species (Table 1). NRCS (1999) grouped state WHIP priorities into upland wildlife, wetland wildlife, riparian and instream aquatic wildlife, and threatened and endangered species habitat categories. Nationwide, over 80% of state plans targeted upland wildlife habitats, especially grasslands (Table 1). Riparian areas also were emphasized in regions outside of the southeastern United States.

*... over 80% of state plans targeted upland wildlife habitats, especially grasslands ... Riparian areas also were emphasized ...*

### **WHIP Was Popular with Landowners and Conservation Partners**

Of the \$50 million available for WHIP in 1998 or 1999, \$30 million was distributed to states for financial and technical assistance in 1998 and \$20 million in 1999. This resulted in 4,600 projects affecting 672,000 acres in 1998 and 3,855 projects on 721,249 acres in 1999. WHIP projects averaged 146 (1998) or 187 (1999) acres in size and \$4,600 in cost-share. The \$10,000 limit on WHIP contracts challenged the states' ability to address ambitious

wildlife goals and tended to favor smaller projects. Nonetheless, the program's flexibility also allowed state conservationists to exceed the \$10,000/contract limit where justified. Thus, in spite of WHIP's ambitious goals and limited funding, states were successful identifying specific management issues and enlisting landowners' participation in addressing them (Burke 1999).

## Partnerships Contributed to Program Support and Efficiency

The diversity of projects initiated under WHIP required NRCS to forge new partnerships in addition to those that had been in place since the 1985 Food Security Act. These new partners helped to develop state priorities and provided additional resources and expertise. WHIP projects involved partnerships with local conservation districts; state wildlife, forestry, and water quality agencies; U.S. Fish and Wildlife Service; nongovernment organizations such as Ducks Unlimited, Quail Unlimited, Rocky Mountain Elk Foundation, Pheasants Forever, Trout Unlimited, The Nature Conservancy, and Mississippi Fish and Wildlife Foundation; and many other groups (NRCS 1999). The Souadabscook stream restoration project in Maine was accomplished under WHIP and illustrates the program's nontraditional nature and cost efficiency (<http://www.WL.fb-net.org/whip/me-souad/Souadabscook.htm>).

WHIP partnerships also were evident in states that sought funding to establish educational programs. Such projects serve to inform the public about wildlife and the important role that farmers, ranchers, and other private landowners play in providing important habitat. Two examples are

■ In North Dakota, a partnership between conservation districts, school districts, and the state wildlife agency to develop 25 outdoor wildlife learning sites (OWLS).

■ In Mississippi, a cooperative project with the Choctaw Indians to create an outdoor learning center for school groups and the general public to increase awareness of the importance of wetland and upland habitats.

## Summary

The diversity of wildlife concerns in America's agricultural landscapes is evident in the different approaches adopted by states in their WHIP plans. States used WHIP to restore components of declining native plant communities, wetlands, riparian areas, aquatic habitat, and other wildlife habitat associated with agricultural landscapes. Work on the priority habitats had the potential to affect numerous terrestrial and aquatic species.



NRCS biologist and landowners at oak savannah restoration (W. Hohman)

*States used WHIP to restore components of declining native plant communities, wetlands, riparian areas, aquatic habitat, and other wildlife habitat associated with agricultural landscapes.*

A review of the state-by-state priorities and the Program Accomplishments Reports highlights the wide breadth of species and native habitats considered by WHIP (NRCS 1999). Beneficiaries of WHIP include economically, culturally, and ecologically important fish and wildlife species (e.g., northern bobwhite quail, Atlantic salmon, Karner blue butterfly, and various species of bats) and rare native habitats in longleaf pine, prairie, and riparian ecosystems.

Many WHIP participants were primarily interested in managing their property for wildlife rather than incorporating wildlife management into agricultural operations. The strong emphasis on wildlife created controversy among traditional beneficiaries of USDA conservation programs who viewed working with owners of nonagricultural lands as “poaching” funds intended for wildlife habitat enhancement on agricultural lands. Burke (1999) reviewed this issue and concluded that whereas state plans addressed both situations, emphasis was given to improving wildlife habitats in agricultural landscapes.

*WHIP provided support for conservation activities not eligible under other USDA programs and therefore complemented other conservation programs.*

WHIP provided support for conservation activities not eligible under other USDA programs and therefore complemented other conservation programs. Wildlife is now recognized as an important component of other programs such as Conservation Reserve and Wetlands Reserve Programs. WHIP contributed to an increased awareness among conservation interests about the potential of USDA conservation programs for improving fish, wildlife, and native habitats in the United States (NRCS 1995).

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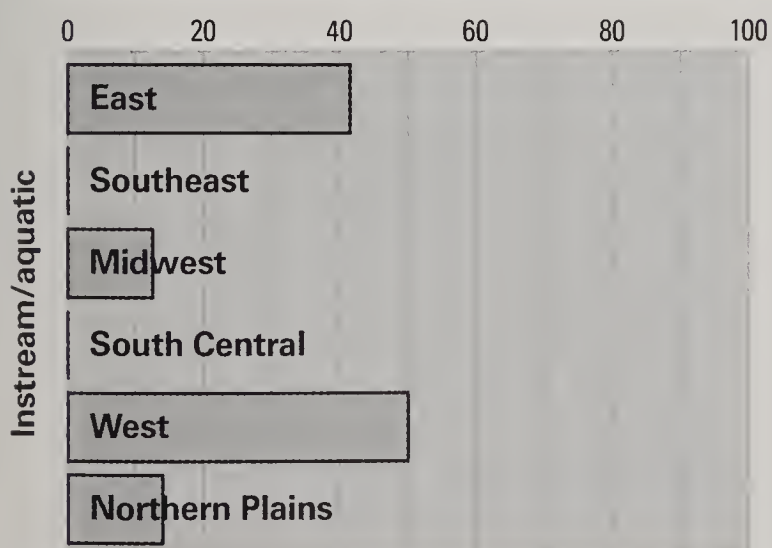
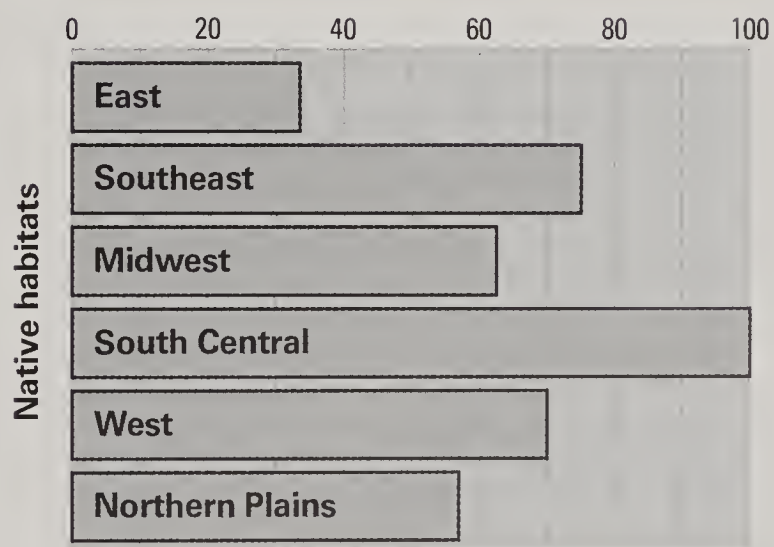
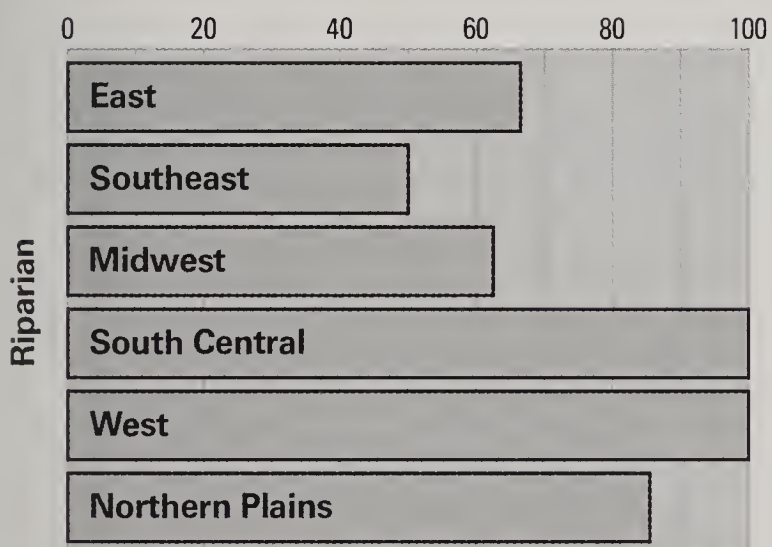
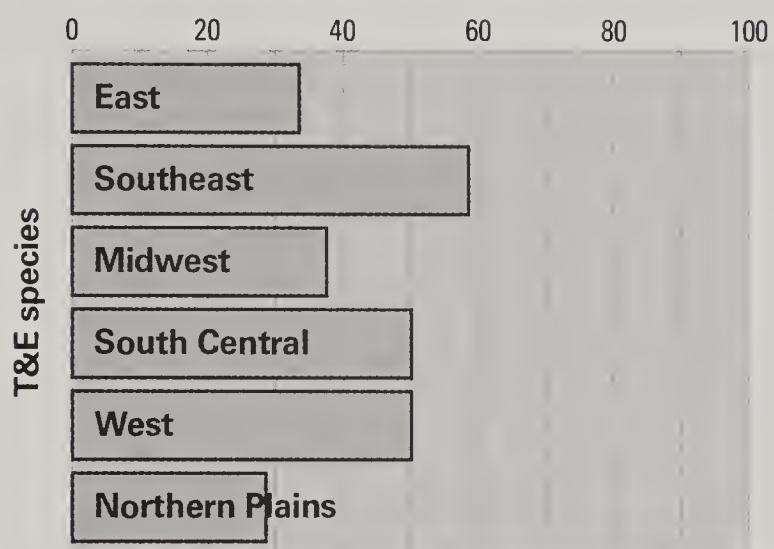
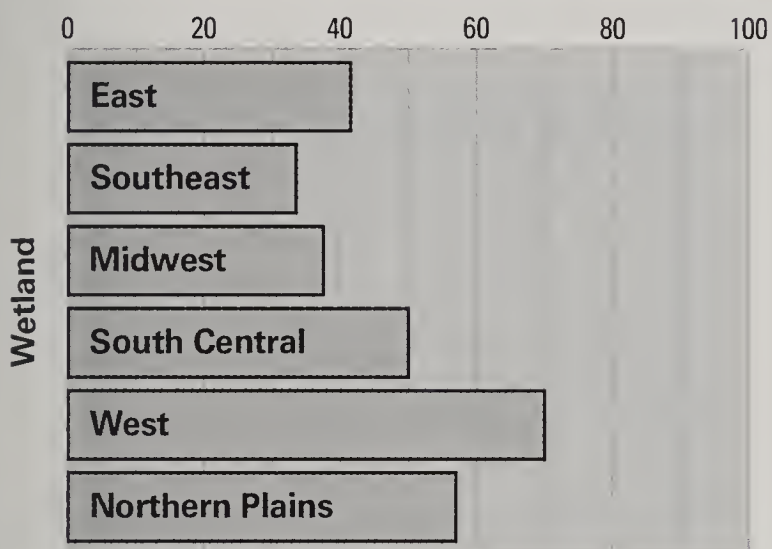
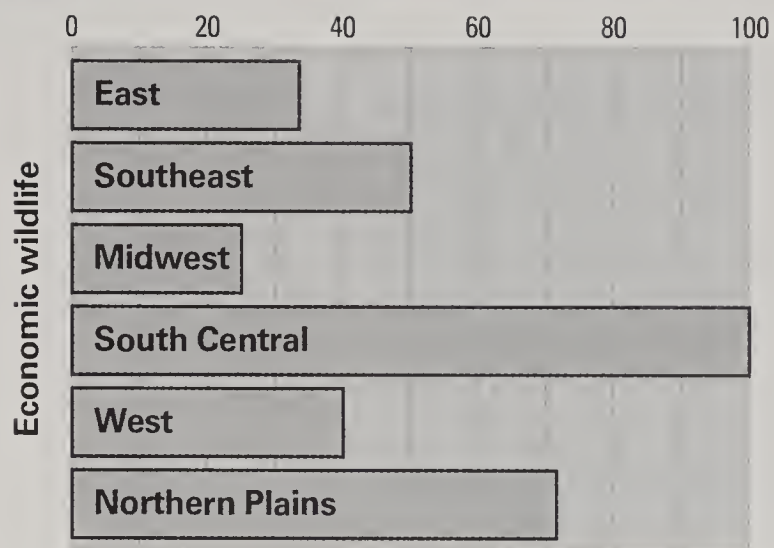
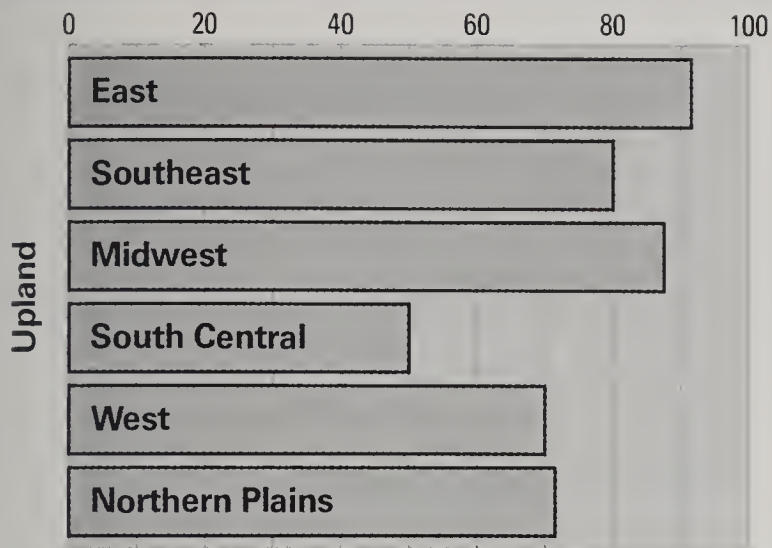
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# Environmental Quality Incentives Program (EQIP)

## Program Summary and Potential for Wildlife Benefits

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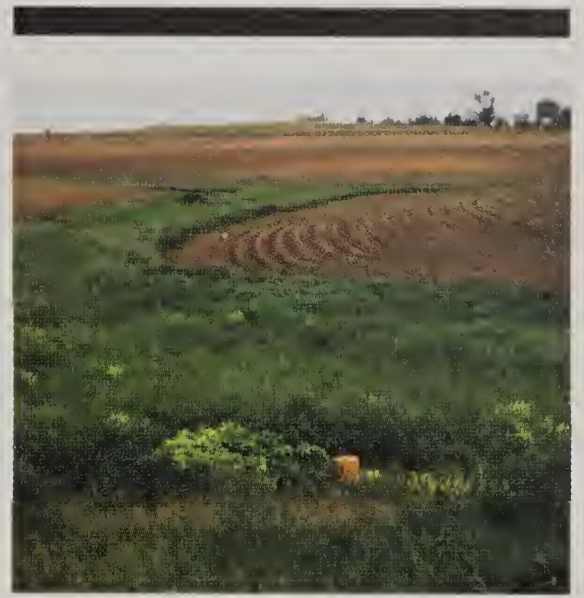
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### Program Description

The Environmental Quality Incentives Program (EQIP) was established in the 1996 Farm Bill to provide a voluntary conservation program for farmers and ranchers who face serious threats to soil, water, and related natural resources, including grazing lands, wetlands, and wildlife habitat. Four of USDA's former conservation programs were combined in EQIP: the Agricultural Conservation Program, Water Quality Incentives Program, Great Plains Conservation Program, and the Colorado River Basin Salinity Control Program. EQIP offers financial, educational, and technical help for installing structural conservation practices, establishing vegetation, and implementing management practices through voluntary five- to ten-year contracts for most agricultural land uses.



Illinois grassed waterway (P. Buck)

*The Environmental Quality Incentives Program (EQIP) was established in the 1996 Farm Bill to provide a voluntary conservation program for farmers and ranchers who face serious threats to soil, water, and related natural resources, including grazing lands, wetlands, and wildlife habitat.*

## **Priority Areas and Locally Led Conservation**

EQIP works primarily in priority areas where significant natural resource problems exist. In general, priority areas are defined as watersheds, regions, or areas of special environmental sensitivity or having significant soil, water, or related natural resource concerns. These concerns could include soil erosion, water quality and quantity, wildlife habitat, wetlands, and forest and grazing lands. These priority areas are identified through a locally led conservation process. Conservation districts convene a local work group comprised of the district board members and key staff; Natural Resources Conservation Service (NRCS) staff; Farm Service Agency (FSA) county committees and key staffs; Cooperative State Research, Education, and Extension Service; other federal, state, and local agencies; nongovernmental organizations; and individuals interested in natural resource conservation, including tribal representatives.

*Priority area proposals are submitted to the NRCS State Conservationist, who prioritizes these proposals within the state based on the recommendations from the State Technical Committee.*

The local work group identifies program priorities by completing a natural resource needs assessment and develops proposals for priority areas based on that assessment. Priority area proposals are submitted to the NRCS State Conservationist, who prioritizes these proposals within the state based on the recommendations from the State Technical Committee.

EQIP also can address additional significant statewide concerns that may occur outside designated priority areas. USDA guidelines require that no less than 65 percent of allocated EQIP funds be directed toward addressing natural resource problems in priority areas and 35 percent of the funds are used to address statewide natural resource concerns. In FY 1999 and FY 2000, state-directed funding targeted to priority areas was approximately 85 percent.

## **Conservation Plans**

All EQIP activities must be carried out according to a conservation plan. Conservation plans are site-specific for each farm or ranch and can be developed by producers with help from NRCS or other service providers. Producers' conservation plans should address the primary natural resource concerns identified by the local working group. All plans are subject to NRCS technical standards adapted for local conditions and are approved by the conservation district. Producers are encouraged to develop comprehensive or total resource management plans.

## **Contracts**

EQIP is delivered to producers through five- to ten-year contracts that provide incentive payments and cost-sharing for conservation practices called for in site-specific plans. Contract applications are accepted throughout the year. NRCS conducts an evaluation of the environmental benefits associated with projects proposed in each producer application. Offers are then ranked according to criteria developed with the advice of the local work group.

Applications are ranked according to environmental benefits achieved, weighted against the costs of applying the practices. Higher rankings are given to plans developed to treat priority resource concerns to a sustainable level. The FSA County Committee approves the highest priority applications for funding. In this manner, EQIP seeks to maximize environmental benefits per conservation dollar spent.

### **Contract Payments**

Program participants receive cost-sharing of up to 75 percent of the costs of certain conservation practices, such as grassed waterways, filter strips, manure management facilities, capping abandoned wells, and other practices important to improving and maintaining the health of natural resources in the area. Incentive payments may be made to encourage a producer to perform land management practices such as nutrient management, manure management, integrated pest management, irrigation water management, and wildlife habitat management. These payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the program incentive. EQIP payments are limited to \$10,000 per person per year and \$50,000 for the length of the contract.

### **Eligibility**

Eligibility is limited to persons who are engaged in livestock or other agricultural production. Eligible land includes cropland, rangeland, pasture, forestland, and other farm or ranch lands. The 1996 Farm Bill prohibits owners of large confined livestock operations from being eligible for cost-share assistance for animal waste storage or treatment facilities. However, technical, educational, and financial assistance may be provided for other conservation practices on these “large” operations. In general, USDA has defined a large confined livestock operation as an operation with more than 1,000 animal units. But, because of differences in operations and environmental circumstances across the country, the national definition of a large confined livestock operation may be amended in each state by the NRCS State Conservationist, after consultation with the State Technical Committee, and approval by the NRCS Chief.

### **EQIP Funding and Program Demand**

EQIP is funded through the Commodity Credit Corporation (CCC), which also funds several other USDA conservation programs. The 1996 Farm Bill authorized up to \$200 million of CCC funds per year be used to fund EQIP through 2002, with 50 percent of those funds dedicated for practices addressing concerns related to livestock production. During the first two years that EQIP was operational (FY 1997 and 1998), the full \$200 million was appropriated for the program. However, in each of FY 1999 and FY 2000, only \$174 million was appropriated for EQIP.

*1996 Farm Bill authorized up to \$200 million of CCC funds per year be used to fund EQIP . . .*

Through FY 1999, more than 2,100 priority areas had been submitted to state conservationists. However, funding is available for only about 360 of these priority areas annually. To date, funding has been provided to 1,470 priority areas to address at least some of the natural resource concerns identified. Additionally, over 56,000 individual EQIP applications were submitted to NRCS by producers in FY 1999. Though approximately 19,000 of these applications were approved for funding, over \$233 million in proposed projects remained unfunded in FY 1999 alone.

### **Fish and Wildlife Benefits**

No specific assessments of the fish and wildlife benefits derived from EQIP are currently available. However, some generalizations can be made from what is known about the biological aspects of the types of conservation practices being installed through EQIP. As of January 1, 2000, over 623,500 EQIP conservation practices (all states) were planned, with over 97,500 of these practices (16 percent) implemented. Although most EQIP practices installed directly or indirectly affect fish and wildlife resources, some practices are more likely to result in tangible habitat benefits (Table 1). By installing buffers and other wildlife-friendly practices, wildlife habitats on agricultural landscapes can be significantly improved (Koford and Best 1995). EQIP provides one mechanism for making these wildlife habitat improvements.

*As of January 1, 2000, over 623,500 EQIP conservation practices (all states) were planned, with over 97,500 of these practices (16 percent) implemented.*

### **Conservation Buffer Practices**

Over 10,000 individual conservation buffer practices have been planned for installation nationwide through EQIP. Although many of these practices have not yet been installed, they represent a significant potential to benefit fish and wildlife resources. Conservation buffer practices provide strip habitats in agricultural landscapes that are used by nesting birds (Best et al. 1995), mammals (Morgan and Gates 1983), and other wildlife (Friesen 1994). Filter strips and riparian buffers also provide water quality benefits, frequently protecting the integrity and restoring the quality of in-stream aquatic habitats (Whitworth and Martin 1990, Welsch 1991, Reay 1997).

### **Fencing**

Landowners are receiving a significant amount of EQIP assistance to install livestock fencing. This practice facilitates excluding livestock from streams and other environmentally sensitive areas, improving fish and wildlife habitat quality at these sites. Fencing also enables producers to improve and implement grazing practices, enhancing range conditions and improving upland wildlife habitat quality. Managed grazing can be a very useful tool to improve wildlife habitat in grassland communities (Kie and Loft 1990, Howe 1999). Current planned projects will eventually result in over 23,000 fencing projects implemented.

## Ponds

In many situations, installation of ponds has significant potential to improve habitat for waterfowl (Ruwaldt et al. 1979, Svingen and Anderson 1998), reptiles and amphibians (Fowler et al. 1985, Hecnar and M'Closkey 1998) and other wildlife. Over 3,200 pond practices have been installed through EQIP. Though no quantitative assessment has been done, these practices are likely providing locally significant wildlife benefits.

## Upland Wildlife Habitat Management

Upland wildlife habitat management practices include a wide variety of practices intended to improve upland habitat quality and quantity. Management actions include planting vegetation that provides wildlife food and cover and manipulating the quality and distribution of wildlife cover types used for nesting, brood rearing, escape cover, winter cover, and other wildlife life history requirements. Management actions taken are based on an appraisal of the habitat quality for target wildlife species or groups. Over 27,500 upland wildlife habitat management practices are currently planned for funding through EQIP. Since only about five percent of these practices have been installed, it is difficult to assess the actual wildlife benefits that have been realized so far.

## Wetland Restoration and Management

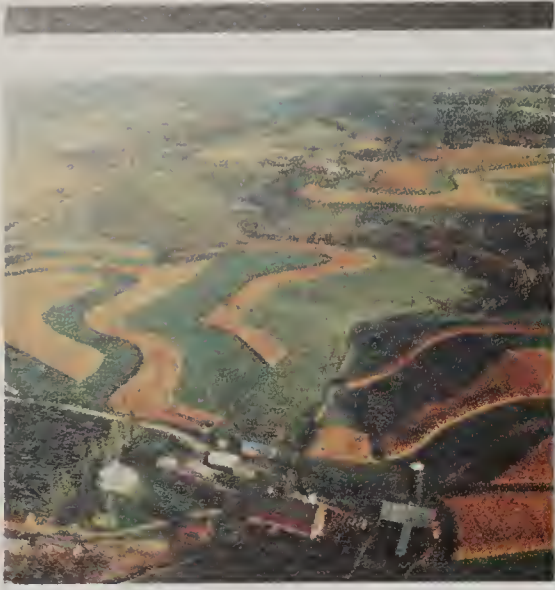
Over 5,200 wetland wildlife management and wetland restoration practices are currently planned. These practices have the potential to improve wetland wildlife habitat quantity and quality. Active wetland management for wildlife and restoration of degraded wetlands are well known for providing benefits to fish and wildlife (Weller 1990, Sewell and Higgins 1991). While many of these EQIP wetland practices have yet to be installed, the potential for local wildlife habitat improvement through these practices is significant.

## Conclusion

The majority of EQIP practices planned and approved for funding have yet to be installed. In addition, only about 13 percent of these practices are generally considered wildlife-oriented practices. However, a large percentage of the remaining practices, such as nutrient management and erosion control, benefit wildlife through water quality improvements. Therefore, it is beyond the scope of this effort to quantify the fish and wildlife benefits derived from EQIP to date. Additional monitoring and research are needed to adequately assess the value of installed EQIP practices to fish and wildlife.

Most EQIP practices have the potential to provide some benefits to fish and wildlife resources if they are planned with these resources in mind. The stated program purposes are to provide technical and financial assistance to farmers and ranchers who face the most serious threats to soil, water,

***Most EQIP practices have the potential to provide some benefits to fish and wildlife resources if they are planned with these resources in mind.***



Iowa conservation system (Tim McCabe)

and related natural resources, including grazing land, wetlands, and wildlife habitat. Practices with the primary purpose of addressing threats to soil and water and grazing lands can be planned to also address habitat needs of important fish and wildlife resources identified by local work groups. In this manner, EQIP can be used as a powerful fish and wildlife habitat enhancement tool while addressing a broad range of natural resource concerns in agricultural landscapes.

*“I’ve been involved with EQIP and have used the program to address a number of natural resource issues—from controlling erosion to keeping the water in my ditches clean. I feel that all the conservation practices I’ve installed through EQIP have definitely provided secondary benefits for the many species of wildlife that call our land home.”*

—Steve Williams, Producer  
Brocton, Illinois

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**Table 1. EQIP conservation practices planned and installed through December 1999 that are likely to provide fish and wildlife benefits.**

Conservation Practice	Number of Practices	
	Planned	Installed
Buffer practices		
Contour buffer strips	49	4
Field border	1,414	236
Field windbreak	74	3
Filter strip	2,598	
Filter strip—trees and shrubs	226	27
Hedgerow planting	140	28
Riparian herbaceous cover	18	—
Riparian forest buffer	1,474	77
Windbreak/shelterbelt establishment	3,504	939
Windbreak/shelterbelt renovation	509	161
<b>Total buffer practices</b>	<b>10,003</b>	<b>1,826</b>
Fence	23,179	6,302
Fish stream improvement	108	25
Pond	7,347	3,289
Tree/shrub establishment	2,994	987
Upland wildlife habitat management	27,519	1,194
Wetland restoration	343	70
Wetland wildlife habitat management	4,940	176
Wildlife watering facility	204	42
<b>Total wildlife-oriented practices</b>	<b>76,637</b>	<b>13,911</b>

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# Appendix I: Wildlife Response to Wetland Restoration and Creation: An Annotated Bibliography

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This annotated bibliography provides summaries of published literature on topics related to wildlife use and other biological responses to wetland restoration and creation. While some articles on estuarine wetlands are included, the focus of this effort is on inland freshwater wetland restoration and creation. Publications specific to water quality, flood abatement, and other wetland functions and values are excluded unless they also cover aspects of biological response. Similar bibliographies have been assembled by other authors in the past. The purpose of this bibliography is to complement previous works and to provide a narrower wildlife focus on recent peer-reviewed papers and publications. Unpublished data, reports, and other "gray literature" are not included.

Almendinger, J. E. 1998. A method to prioritize and monitor wetland restoration for water-quality improvement. *Wetlands Ecology and Management* 6:241-251.

Method developed for prioritizing wetland restoration sites to maximize water quality improvement benefits was applied to the Minnesota River Basin. Wetlands were assessed for their potential to provide water quality benefits using three types of effectiveness: (1) problem effectiveness (Did the site occur in an area with known water quality problems?); (2) function effectiveness (Was the site likely to improve water quality more or less than other sites?); and (3) information effectiveness (Did the site fit within a research plan to gain information on how wetlands improve water quality?). While water quality benefits were emphasized, the paper recognizes that wetland restoration should be multidisciplinary, integrating other benefits such as wildlife habitat and flood abatement.

Anderson, B. W., and R. D. Ohmart. 1984. Avian use of revegetated riparian zones. Pages 626-631 in R. E. Warner and K. M. Hendrix, eds. *California riparian systems: ecology, conservation, and productive management*. California Water Resources Report 55. University of California Press, Berkeley.

Study of avian use of revegetated riparian areas along the lower Colorado River. Vegetation growth and avian colonization occurred rapidly after restoration. Cottonwood, willow, and quail bush were positively associated with avian use. Avian use of riparian areas was further enhanced by elimination of exotic salt cedar and leaving native vegetation.

Anderson, B. W., R. D. Ohmart, and J. Disano. 1979. Revegetating the riparian floodplain for wildlife. Pages 318-331 in R. R. Johnson and J. F. McCormick, tech. coords. *Strategies for protection and management of floodplain wetlands and other riparian ecosystems*. U.S. Forest Service General Technical Report WO-12.

Study of bird responses to vegetation characteristics along the lower Colorado River. Horizontal and vertical foliage diversity and presence of cottonwood and/or willow trees were positively correlated with the number of bird species using an area. Presence of the exotic salt cedar was negatively associated with both bird density and number of species present. Growth of annual plants in riparian floodplain areas was important for attracting large concentrations of wintering birds the first winter after planting.

Anderson, R. E. 1991. Wisconsin wetlands restored. *Soil and Water Conservation News* 12:14.

Description of wetland restoration activities on CRP lands in Ozaukee County, Wisconsin. In two years, 110 small wetlands were restored. After having been cropped for decades, wetland plants returned to restored wetlands the year following restoration. Monitoring of restored wetlands documented use by ducks and duck broods, meadow voles, butterflies, American toads, green frogs, leopard frogs was mentioned. Marsh wrens, sandpipers, and woodcock began nesting in restored wetlands two years after establishment.

Barry, W. J., A. S. Garlo, and C. A. Wood. 1996. Duplicating the mound-and-pool microtopography of forested wetlands. *Restoration and Management Notes* 14:15-21.

A method was described for establishing pit-and-mound microtopography while creating a forested wetland on degraded uplands in New Hampshire. Approximately 128 acres of former sand and gravel pits were developed into forested wetland to meet mitigation requirement of a highway construction project. Pit-and-mound microtopography was established with a bulldozer so that half the area was occupied by mounds (16-ft base width, 4-ft top width, and 2-ft height above pit bottoms) and half the area was occupied by pools. Wetland topsoil was spread over the area. Bare-root seedlings of woody plants were planted in the pools and on the sides of mounds, while larger balled and burlap and container stock trees and shrubs were planted on tops of mounds. Plantings were irrigated during summer and early fall to aid establishment. Follow-up monitoring of the vegetation showed a high rate of success from planting stock and natural regeneration.

Bedford, B. L. 1999. Cumulative effects on wetland landscapes: Links to wetland restoration in the United States and southern Canada. *Wetlands* 19:775-788.

Analysis of cumulative wetland impacts from a regional perspective was recommended for wetland restoration planning. To characterize the diversity of settings created by the complex interactions of hydrology, geology, and climate in specific landscapes, assessments should identify the kinds, numbers, relative abundance, and spatial distribution of wetland templates. These profiles should be used to guide wetland restoration decision-making to match wetland type and location to proper hydrogeologic setting, thereby increasing the chance for success of individual restoration projects.

Bijlmakers, L. L., and E. O. A. M. de Swart. 1995. Large-scale wetland-restoration of the Ronde Venen, The Netherlands. *Water Science and Technology* 31:197-205.

A plan for large-scale wetland restoration and improvement of water quality in a hydrologic unit in The Netherlands was presented. Major elements of the strategy were the optimal use of specific hydrological and ecological characteristics of the area.

Brown, S. C. 1999. Vegetation similarity and avifaunal food value of restored and natural marshes in northern New York. *Restoration Ecology* 7:56-68.

Development of plant communities in 13 restored emergent wetlands in northern New York was contrasted to nearby natural wetlands for three years following restoration. More plant species valuable as food sources for wetland birds and greater coverage of

these species occurred in restored wetlands than in natural wetlands. In general, plant communities at restored sites became increasingly similar to those of natural wetlands over time. Natural recolonization appeared to be an effective technique for restoring wetlands on abandoned agricultural fields.

Brown, M., and J. J. Dinsmore. 1986. Implications of marsh size and isolation for marsh bird management. *Journal of Wildlife Management* 50:392-397.

Study examined bird use of Iowa's prairie marshes in relation to wetland size and proximity to other wetlands. Marsh size and isolation from other marshes explained 75 percent of the variability in bird species richness. Species richness was often greater in wetland complexes than in larger isolated marshes. Authors concluded that marsh size and isolation were important considerations in siting marsh restorations.

Brown, S. C., and C. R. Smith. 1998. Breeding season bird use of recently restored versus natural wetlands in New York. *Journal of Wildlife Management* 62: 1480-1491.

Bird use of 18 restored wetlands and eight natural herbaceous wetlands in northern New York was documented during the three-year period following restoration. Abundance of bird species and individuals did not differ between restored and natural wetlands for all three bird groups studied (wetland-dependent, wetland-associated, and nonwetland birds). Bird density appeared lower at recently restored wetlands than at natural wetlands. Bird communities were more similar among restored sites than between restored and natural wetland sites. Differences in bird similarity between natural and restored wetlands may disappear as restored wetlands develop over time.

Brown, S. C., K. Smith, and D. Batzer. 1997. Macroinvertebrate responses to wetland restoration in northern New York. *Environmental Entomology* 26:1016-1024.

Macroinvertebrate communities in recently restored wetlands in northern New York were contrasted with those of comparable natural wetlands in the same area. Most invertebrate taxa found in natural wetlands also could be found in similar numbers in restored wetlands. Insects with aerial dispersal colonized restored wetlands more rapidly than less mobile invertebrates. Transfer of remnant wetland soil increased rate of wetland plant growth and overall invertebrate abundance. Use of this technique, along with reintroduction of some less mobile taxa, could improve efforts to reestablish natural macroinvertebrate communities to newly restored wetlands.

Burney, J. L. Jr., S. T. Bacchus, and J. B. Lee. 1989. An evaluation of wildlife utilization in a man-made freshwater wetland system in central Florida, U.S.A. Pages 24-48 in F. J. Webb Jr., ed. *Proceedings of the 16th Annual Conference on Wetlands Restoration and Creation*. Hillsborough Community College, Plant City, Florida.

A 1,200-acre wetland complex (deep marsh, mixed marsh, created hardwood swamp, littoral zone) was constructed on and adjacent to Lake Chipster near Orlando, Florida, to process tertiary treated wastewater from a nearby Orlando wastewater treatment facility. Wildlife species observed using the complex were documented from Spring 1987 (prior to the first release of wastewater into the wetland but after wetland construction had commenced) to Spring 1989. Visual/auditory observations and various trapping methods were used to determine species composition.

Colburn, B. 1997. Once-upon-a-time-wetlands. *Sanctuary* 36:16-18.

The challenge of restoring freshwater wetland was discussed. Projects in California and Massachusetts were described to illustrate how wetland restoration can benefit both wildlife and human populations.

Confer, S. R., and W. A. Niering, 1992. Comparison of created and natural freshwater emergent wetlands in Connecticut (U.S.A.). *Wetlands Ecology and Management* 2:143-156.

Five 3- to 4-year-old created palustrine/emergent wetland sites were compared with five nearby natural wetlands of comparable size and type. Hydrologic, soil, and vegetation data were compiled over a nearly two-year period (1988-90). Created sites that were located along major highways, exhibited more open water, greater water depth, and greater fluctuation in water depth than natural wetlands. Common cattail was the characteristic emergent vegetation at created sites, whereas a more diverse mosaic of emergent wetland species was often associated with cattails at the natural sites. Wildlife use at all sites ranged from occasional to rare, with more species observed in the natural than created wetlands (39 vs. 29 spp.). Whereas emergent vegetation in created wetlands was frequently restricted to the littoral zone, emergent species were more widely scattered throughout natural wetlands. This pattern in created sites was probably related to their steeply sloped shorelines. The low to moderate wildlife activity at created sites was attributed to their small size as well as their isolation. Authors indicated that > 10 years was needed to adequately assess created wetlands and recommended establishment demonstration areas.

Degani, G., Y. Yehuda, and M. Gophen. 1998. Temporal variation in fish community structure in a newly created wetland lake (Lake Agmon) in Israel. *Wetlands Ecology and Management* 6:151-157.

A 110-ha wetland lake (Lake Agmon) was restored in Israel to encourage ecotourism. Fish were introduced into the lake to control mosquitoes. This study examined the fish community during the first two years following restoration of the lake. Results indicated that the fish community had not stabilized by the end of the second year after restoration.

Deitz, K. B., J. A. O'Reilly, G. S. Podniesinski, and D. J. Leopold. 1996. Rebuilding microtopography and planting woody species restores abandoned agricultural land (New York). *Restoration and Management Notes* 14:171-172.

Methods of restoring wetland plant communities in abandoned New York muck farms were investigated including (1) addition of donor wetland topsoil, (2) artificially creating mounds to mimic natural microtopography, and (3) direct planting of woody species seedlings at various elevations on created hummocks. Herbivory and competition from herbaceous plants resulted in poor seedling survival. When measures were taken to control these factors, seedling survival improved substantially, and species growth and survival were linked to elevation and soil saturation. Results illustrated the importance of restoring microtopography to maximize species richness in forested wetland restorations and limiting water depth around hummocks to discourage muskrats from burrowing into hummocks (which can lead to collapse of soil and flooding of seedlings). To reduce herbivory, measures such as fencing, planting large nursery stock, or transplanting larger trees and shrubs from donor sites should be considered.

Delehanty, D. J., and W. D. Svedarsky. 1993. Black tern colonization of a restored prairie wetland in northwestern Minnesota. *Prairie Naturalist* 25:213-218.

Black tern colonization was documented in a prairie wetland system that was restored five years after being drained. Breeding black terns used the wetland during the second and third breeding seasons after restoration (10 and 26 nests initiated, respectively). Forty adults were present in the marsh during the third breeding season and a minimum of seven young were fledged.

Delphey, P. J., and J. J. Dinsmore. 1993. Breeding bird communities of recently restored and natural prairie potholes. *Wetlands* 13:200-206.

Breeding bird communities of recently restored prairie wetlands in northern Iowa were compared with those of similar natural wetlands. Species richness of breeding birds was higher at natural wetlands; however, duck species richness and pair counts did not differ between natural and restored wetlands. Incomplete vegetation structure at recently restored wetlands likely depressed bird species richness. Drought during the study may have influenced results. Authors concluded that long-term studies during various periods of precipitation were needed to determine success of prairie pothole restoration efforts.

Despain, W. 1995. A summary of the SWCS WRP survey. *Journal of Soil and Water Conservation* 50: 632-633.

Paper summarized results from a 1992 survey of landowners from seven pilot states seeking their perspectives on and reactions to the initial Wetlands Reserve Program. Perspectives among landowners included how wetlands were defined, environmental benefits of wetlands, understanding of governmental and nongovernmental wetlands programs, and perspectives on the role of government in wetland conservation. Three groups of landowners identified by survey included those who (1) expressed no interest in WRP due to lack of program knowledge or program constraints, (2) began the enrollment process, but withdrew because of their frustration with the sign-up process or concerns about financial matters or long duration of easements, and (3) participated in the program.

Detenbeck, N. E., S. M. Galatowitsch, J. Atkinson, and H. Ball. 1999. Evaluating perturbations and developing restoration strategies for inland wetlands in the Great Lakes Basin. *Wetlands* 19:789-820.

Paper evaluated physical and biological responses to wetland perturbations in the Great Lakes Basin. Important disturbance mechanisms included sedimentation and turbidity, changes in retention time, eutrophication, and changes in hydrologic timing. Responses to these disturbances included (1) shifts in plant species composition, (2) reduced wildlife production, (3) decreased local or regional biodiversity, (4) reduced fish and/or other secondary production, (5) increased flood peak/frequency, (6) increased above-ground production, and (8) loss of aquatic plant species with high light compensation points. Authors advocated wetland restoration strategies derived at the ecoregion scale using information on current and historic wetland extent and type distributions, and distributions of species of special concern that are dependent on certain wetland types or habitat type mosaics. Authors further suggested regional strategies promote restoration of all appropriate wetland types.

Dick, T. 1993. Restored wetlands as management tools for wetland-dependent birds. *Pennsylvania Birds* 7:4-6.

Bird use was described for an 80-acre restored wetland site in south-central Pennsylvania. Wetland-dependent birds were observed using this site during the first year after restoration. Bird groups observed included winter raptors, wintering and migrating ducks, geese and tundra swans, foraging wading birds, waterfowl and shorebirds. At least 50 mallard ducklings and numerous wood duck ducklings were produced during the first year. Breeding sora, sedge wrens, common snipe, spotted sandpiper and pied-billed grebe also were documented. The transition from fallow agricultural field to emergent marsh increased bird diversity by 60 percent during the first year.

Elphick, C. S., and L. W. Oring. 1998. Winter management of Californian rice fields for waterbirds. *Journal of Applied Ecology* 35:95-108.

Wintering waterbird use of flooded rice fields with varying water depths and rice straw residue manipulations was studied in the Sacramento River Basin of California's Central Valley. Intentionally flooded rice fields received significantly greater use by 24 of 31 waterbird species studied. No differences were detected among various straw manipulation practices for most species. Several small shorebird species used fields where straw was incorporated into the soil more than fields with less straw manipulation. Species differed in their use of different water depths; however, depth was a poor predictor of bird use. Depths of 15-20 cm resulted in frequent use by the greatest number of species. Flooding of rice fields increased suitable habitat for most waterbird species studied.

Ettema, C. H., D. C. Coleman, and S. L. Rathbun. 1998. Spatiotemporal distributions of bacterivorous nematodes and soil resources in a restored riparian wetland. *Ecology* 79:2721-2734.

Spatial and temporal variability in bacterivorous nematode populations and their relationship to soil characteristics (microbial respiration, inorganic nitrogen, moisture, and soil organic matter) were studied in a 0.7-ha restored riparian wetland in the Coastal Plain of Georgia. Results indicated that spatial distribution within the wetland varied substantially among individual nematode taxa, with substantial temporal variation within taxa. Distribution of nematode taxa did not correlate well with soil resource patterns.

Euliss, N. H., and D. M. Mushet. 1999. Influence of agriculture on aquatic invertebrate communities of temporary wetlands in the Prairie Pothole Region of North Dakota, U.S.A. *Wetlands* 19:578-583.

Paper compared aquatic invertebrate communities of temporary prairie pothole wetlands that were farmed with those that occur in grassland settings. More taxa and greater numbers of cladoceran

resting eggs, planorbid and physid snail shells, and ostracod shells were found in grassland wetlands than farmed wetlands. Authors concluded that the aquatic communities of temporary prairie pothole wetlands were negatively impacted by intensive agriculture.

Fairbairn, S. E. 1999. Local and landscape-level influences on wetland bird communities of the Prairie Pothole Region of Iowa. Thesis. Iowa State University, Ames.

An analysis of the effects of site and landscape characteristics on the number of species and density of wetland birds in Prairie Pothole Region of Iowa, 1997-1998. At the landscape scale, annual differences were detected in relations of habitat features to bird diversity. Significant predictors of diversity were percentage of wetland area in complex with emergent vegetation, total wetland area within 3 km of complex, total area of semipermanent wetlands within 3 km of complex. At local scale, a habitat diversity index measuring the evenness of distribution of various habitats within a wetland was a significant predictor of bird diversity in both years. Models were presented that related habitat characteristics to densities of 18 species of wetland-associated birds.

Fowler, D. K., D. M. Hill, and L. J. Fowler. 1985. Colonization of coal surface mine sediment ponds in southern Appalachia by aquatic organisms and breeding amphibians. Pages 261-285 in R. E. Brooks, D. E. Samuel, and J. B. Hill, eds. *Wetlands and water management on mined lands, proceedings of a workshop*. Pennsylvania State University, School of Forestry, University Park.

Basic water quality parameters were measured and aquatic plants, invertebrates, and breeding amphibians were sampled in nine newly constructed coal surface mine sediment ponds in western Tennessee. Ten species of aquatic plants colonized the ponds; 61 invertebrate taxa were observed the first year of sampling and 44 taxa the second year. Twelve species of breeding amphibians were documented in the study with individual ponds having 1-9 amphibian species. Results provided evidence of rapid colonization of surface mine wetlands by aquatic flora and fauna.

Gabrey, S. W., A. D. Afton, and B. C. Wilson. 1999. Effects of winter burning and structural marsh management on vegetation and winter bird abundance in the Gulf Coast Chenier Plain, U.S.A. *Wetlands* 19:594-606.

Effects of marsh burning to enhance waterbird habitats and manage vegetation in Gulf Coast marshes on nontarget wintering birds were studied through a series of experimental burns in impounded and unimpounded marshes in south Louisiana. Burning of impoundments influenced vegetation structure, which influenced bird

abundance and species composition. Blackbirds preferred recently burned plots, while sparrows and wrens avoided burned plots until vegetation had recovered for one year following burning. The authors recommended patchy burns be used at both local and landscape levels to meet goose management objectives while providing suitable habitats for nontarget birds.

Galatowitsch, S. M., A. G. van der Valk, and R. A. Budelsky. 1998. Decision-making for prairie wetland restoration. *Great Plains Research* 8:137-155.

A conceptual framework was outlined for wetland restoration decision-making in the prairie region based on optimizing wetland restoration success at both landscape and site scales. The framework recognized that restoration efforts should focus on restoring prairie wetland complexes rather than on isolated wetland basins. Authors recommended that concept should be used in evaluating success of prairie wetland restoration efforts.

Galatowitsch, S. M., and A. G. van der Valk. 1996. Characteristics of recently restored wetlands in the Prairie Pothole Region. *Wetlands* 16:75-83.

Basin morphology, hydrology, and vegetation zone development was characterized in 62 recently restored prairie wetlands in Iowa, Minnesota, and South Dakota. In general, restored wetlands had basin morphologies that were comparable to similarly sized natural wetlands. Most restored basins met or exceeded predicted hydrology, although 20 percent of restored wetlands were considered hydrologic failures. Most restored wetlands had developed emergent and submersed aquatic vegetation zones, but only a few developed wet prairie and sedge meadow zones. Restored wetlands were unable to replace wetland complexes due to the limited number of basins affected. Greater emphasis should be placed on restoring complexes of wetlands representing a variety of wetland classes and sizes.

Galatowitsch, S. M., and A. G. van der Valk. 1996. Vegetation and environmental conditions in recently restored wetlands in the Prairie Pothole Region of the U.S.A. *Vegetatio* 126:89-99.

Vegetation, hydrology, and soil and water quality characteristics of 10 natural prairie wetlands in Iowa were compared with 10 restored wetlands three years after reflooding. Restored basins supported more species of submerged aquatic vegetation than did natural wetlands. However, stands of emergent and wet meadow species were sparse in restored wetlands compared to natural wetlands. Fluctuations in water levels were similar for both restored and natural wetlands. Results indicated that propagules of submersed aquatic plants were able to colonize restored basins rapidly, while other guilds of wetland plants may take longer to become established.

Galatowitsch, S. M., and A. G. van der Valk. 1993. Natural revegetation during restoration of wetlands in the southern Prairie Pothole Region of North America. Pages 129-142 in Wheeler, B. D., S. C. Shaw, W. J. Foit, and R. A. Robertson, editors. *Restoration of Temperate Wetlands*. Wiley and Sons, New York.

Sixty-two recently restored prairie pothole wetlands were examined to determine patterns in the composition and structure of the vegetation among restored wetlands and to compare the vegetation of restored wetlands to natural wetlands. Results showed that basins reflooded for three years had approximately half of the wetland plant species of comparable natural wetlands. Ditch-drained wetlands contained refugia of wetland species and were rapidly recolonized by emergent perennial wetland plants that propagated vegetatively. Tile-drained basins were more thoroughly drained and lacked wetland plant refugia; these basins were typically colonized by mudflat annuals and submersed aquatics upon reflooding. Recolonization of these restored tile-drained basins was likely due to dispersal rather than recruitment from the seed bank. Regardless of drainage history, restored prairie wetlands lacked the perimeter zones of wet prairie and sedge meadow vegetation.

Gibbs, J. P. 1993. Importance of small wetlands for the persistence of local populations of wetland-associated animals. *Wetlands* 13:25-31.

Loss of small, legally unprotected wetlands in a 600-km<sup>2</sup> area in Maine was modeled to assess potential impacts to wetland-associated wildlife populations. Loss of small wetlands resulted in a 19% decline in total wetland area, a 62% decline in total wetland number, and a 67% increase in average inter-wetland distance. Landscape available for terrestrial-dwelling, aquatic-breeding amphibians, based on a 1,000-m maximum migration distance, decreased from 90% with small wetlands to 54% without small wetlands. The model indicated that local populations of turtles, small birds, and small mammals, stable under conditions with small wetlands, faced a significant risk of extinction after loss of small wetlands. Simulation provided evidence of the importance of small wetlands for certain taxa of wetland animals.

Gonzales Martinez, S. C., and L. F. Valladares Diez. 1996. The community of Odonata and aquatic Heteroptera (Gerromorpha and Nepomorpha) in a rehabilitated wetland: the Laguna de la Nava (Palencia, Spain). *Archiv fur Hydrobiologie* 136:89-104.

The Odonata and aquatic Heteroptera communities in a restored wetland in northern Spain was characterized. Aquatic Heteroptera species richness in the restored wetland was higher than that recorded in other saline permanent waters. Species of both ubiquitists and pioneers were associated with immature wetlands. The presence of some long-lived dragonflies and heteropterans with

little mobility indicate a certain maturity of the system. In general, the communities of dragonflies and aquatic heteropterans were representative of recent wetlands, with evidence of changes toward a more stable and mature environment.

Guggisberg, A. C. 1996. Nongame bird use of restored wetlands in Manitowoc County, U.S. Fish and Wildlife Service and Partners for Wildlife Program Final Report. Wisconsin Department of Natural Resources, Madison. 60 pp.

Nongame bird use and vegetation growth were summarized for 143 recently restored herbaceous wetlands in southeastern Wisconsin. Cattails quickly colonized smaller restored wetlands, while larger basins developed greater vegetation diversity. Shorebird use of restored wetlands was very limited. In general, large restored wetlands had greater nongame bird species richness than did small wetlands.

Hashisaki, S. 1996. Functional wetland restoration: An ecosystem approach. *Northwest Science* 70:348-351.

Review of the history of wetland mitigation and evolution of functional restoration. The author also described the tools that have been developed specifically to support the move toward functional wetland restoration, including the hydrogeomorphic wetland classification system and the associated functional assessment methodology.

Hemesath, L. M., and J. J. Dinsmore. 1993. Factors affecting bird colonization of restored wetlands. *Prairie Naturalist* 25:1-11.

Breeding marsh birds were surveyed in restored wetland basins in northern Iowa. Bird species richness increased with wetland size but was unrelated to age of restored wetlands. Birds rapidly colonized restored wetlands, usually in the first year after restoration. Duration of drainage affected development of marsh vegetation but had no effect on bird species richness. Authors recommended that restoration efforts concentrate on large wetland basins that were recently drained or frequently flood.

Hey, D., and N. S. Filippi. 1995. Flood reduction through wetland restoration: The Upper Mississippi River Basin as a case history. *Restoration Ecology* 3: 4-17.

In light of the failure of large-scale flood control measures to reduce impacts of flooding in the Mississippi River Basin, authors presented a flood management strategy that used wetlands to intercept and hold precipitation and reduce flood flows. The strategy maintains that the basin's flooding problems can be solved in an ecologically sound manner by restoring 13 million acres of wetlands on existing drained hydric soils in the basin.

Hruby, T., and M. Scuderi. 1995. Integrated planning for wetland restoration and mitigation. *Restoration and Management Notes* 13:45-46.

Authors described an integrated planning process to replace lost wetland function attributed to potential development in the Mill Creek Basin in King County, Washington. A Special Area Management Plan under development would ensure performance of wetland function and allow continued economic growth and expansion in the basin.

Johnson, P. 1996. The role of U.S. agricultural programs in protecting waterfowl. Pages 9-11 in J. T. Ratti, ed. *Proceedings of the 7th International Waterfowl Symposium*. Ducks Unlimited, Inc., Institute for Wetlands and Waterfowl Research, Memphis, Tennessee.

The author described the history of the Natural Resources Conservation Service (NRCS) and provided examples of how agencies could work together with private landowners to conduct conservation work on private lands to benefit waterfowl and other wildlife. USDA conservation programs such as the Conservation Reserve Program, Wetlands Reserve Program, and Small Watersheds Program, and the technical assistance provided to landowners by NRCS conservationists and other government and private technicians were identified as critical elements of implementing conservation on the land.

King, S. L., and B. D. Keeland. 1999. Evaluation of reforestation in the Lower Mississippi River Alluvial Valley. *Restoration Ecology* 7:384-359.

Efforts to restore bottomland hardwood forest in the Lower Mississippi River Alluvial Valley were reviewed based on a survey of individuals involved in wetland restoration activities. Over the past 10 years, 77,698 ha were reforested, with an additional 89,009 ha planned for reforestation in the next five years. Oaks were the most common species planted, and bare root seedlings were the most common plant materials used. Reforestation efforts were based upon the principles of landscape ecology, but local problems such as drought, herbivory, and flooding limited success. While broad-scale hydrologic restoration was desired, significant past hydrologic alterations and social considerations frequently limited extent of hydrology restoration feasible. Local hydrologic alteration to provide habitat features was important. More extensive analysis was needed to evaluate functional success of these efforts. Authors concluded that additional incentives like the Wetlands Reserve Program were needed to expand reforestation activities on private lands.

Lacki, M. J., J. W. Hummer, and H. J. Webster. 1991. Avian diversity patterns at a constructed wetland: Use of ecological theory in the evaluation of a mine land reclamation technique. *International Journal of Surface Mining and Reclamation* 5:101-105.

Birds were surveyed at a constructed cattail wetland in Ohio. Comparison surveys also were completed at three nearby natural wetlands. Results demonstrated the constructed wetland exhibited the fewest number of bird feeding guilds per survey and an intermediate level of bird abundance relative to all sites examined. The constructed wetland supported a bird community with a significantly lower species evenness index, suggesting a more harsh and variable habitat relative to the natural wetlands. Data suggested that the availability of adequate nesting habitat strongly influenced the patterns for avian diversity observed.

Lacki, M. J., J. W. Hummer, and H. J. Webster. 1992. Mine-drainage treatment wetland as habitat for herpetofaunal wildlife. *Environmental Management* 16:513-520.

Reptile and amphibian use of a wetland constructed for treatment of mine water drainage in east-central Ohio was compared to herpetofauna in natural wetlands within the surrounding watershed. The constructed wetland supported the greatest abundance and species richness of herpetofauna among the sites surveyed, primarily due to the large number of green frogs and pickerel frogs and numerous species of snakes found using this site. Results reveal that wetlands created for water quality improvements can provide habitat for reptiles and amphibians.

Langston, M. A., and D. M. Kent. 1997. Fish recruitment to a constructed wetland. *Journal of Freshwater Ecology* 12:123-129.

The fish community of a 31.6-ha constructed wetland in east-central Florida was sampled over a two-year period. A rich and abundant fish community rapidly developed. This community was similar to that of natural wetlands in the area. Fish may have been introduced to the study wetland by irrigation, transport on terrestrial or flying animals, or a combination of sources.

Lant, C. L., S. E. Kraft, and K. R. Gillman. 1995. The 1990 Farm Bill and water quality in corn belt watersheds: Conserving remaining wetlands and restoring farmed wetlands. *Journal of Soil and Water Conservation* 50:201-205.

A mail and interview survey was conducted in 10 corn belt counties to (1) assess interest in enrolling farmed wetlands in CRP and WRP and (2) elicit farmer and landowner attitudes toward Swampbuster. Enrollment of farmed wetlands into CRP increased from 2-8% of eligible acreage at an annual rental rate of \$90/acre/yr to 52-64% at \$140/acre/yr to 81-83% at \$400/acre/yr. Potential for WRP enrollments increased from 4% of eligible acreage at \$500/acre for a 30-yr easement to 26% at \$2,500/acre. Swampbuster was highly unpopular with 68% of respondents who claimed that it was a violation of their property rights.

LaGrange, T. G., and J. J. Dinsmore. 1989. Plant and animal responses to restored wetlands. *Prairie Naturalist* 21:39-48.

Plants and animals were surveyed in four formerly drained wetland basins several years after the basins were reflooded. A total of 45 plant species, 18 wetland invertebrate species, and 11 bird species were detected. Duration of drainage was unknown and ages of restorations not specified. Authors concluded that removal or blockage of tile lines was an easy and cost-effective way to restore wetlands.

Lehtinen, R. M., S. M. Galatowitsch, and J. R. Tester. 1999. Consequences of habitat loss and fragmentation for wetland amphibian assemblages. *Wetlands* 19:1-12.

Paper assessed the effects of habitat loss and fragmentation on amphibian assemblages in 21 glacial marshes in Minnesota. Wetlands studied occurred in both tall-grass prairie and northern hardwood forest ecoregions. Amphibian species richness was lower with greater wetland isolation and road density at all spatial scales in both ecoregions. Data suggested that decreases in landscape connectivity through fragmentation and habitat loss can affect amphibian assemblages, and reversing those landscape changes should be an important part of a regional conservation strategy.

Lewis, R. R. III, J. A. Kusler, and K. L. Erwin. 1994. Lessons learned from five decades of wetland restoration and creation in North America. Pages 233-240 in *Proceedings of the Conference on Challenges and Opportunities in the Marine Environment*. Marine Technology Society, Washington, D.C.

Although thousands of wetlands have been restored over the last 50 years, very little effort has been placed on short-term or long-term monitoring of these sites. Authors recommended that restored

wetlands be monitored for rates of revegetation, use by animal species, development of soil profiles, patterns of succession, and evidence of persistence.

Lowrance, R., G. Vellidis, and R. K. Hubbard. 1995. Denitrification in a restored riparian forest wetland. *Journal of Environmental Quality* 24:808-815.

Subsurface water denitrification rates in a newly restored, southeastern coastal plain riparian forested wetland were studied. Restoration consisted of reestablishing woody vegetation in a former riparian forested wetland that had been logged and subsequently grazed for several years; no hydrology modifications were necessary. Denitrification rates were measured monthly within the restored wetland before and after application of liquid manure on adjacent uplands. Denitrification rates were found to be comparable to mature riparian forests.

Malakoff, D. 1998. Restored wetlands flunk real-world test. *Science* 280:371-372.

Author argued that it is difficult to precisely predict vegetation and wildlife response to created tidal wetlands. The failure of a created wetland near San Diego, California, to attract the light-footed clapper rail, a species for which the wetland was constructed to benefit, illustrates this point. Author recommended that additional time and allowance for natural processes to shape the wetland should be considered in implementing mitigation projects.

Mayer, P. M., and S. M. Galatowitsch. 1999. Diatom communities as ecological indicators of recovery in restored prairie wetlands. *Wetlands* 19:765-774.

Diatoms were used to assess the recovery of northern prairie wetlands in eastern South Dakota restored after drainage. Diatom communities in eight natural wetlands were compared with eight restored wetlands. Diatom species richness and composition were similar at restored and natural wetlands. Diversity and equitability at restored and reference sites were similar within a sampling period, but both decreased over the growing season in natural wetlands. Diatoms may have limited use as ecological indicators in prairie wetland because of the unique interaction between diatom life history and the cyclic hydrology of prairie wetlands and because diatom community structure was highly variable among reference wetlands.

McKinstry, M. C., and S. H. Anderson. 1994. Evaluation of wetland creation and waterfowl use in conjunction with abandoned mine lands in northeast Wyoming. *Wetlands* 14:284-292.

Ninety-two wetlands created on formerly mined lands in northeast Wyoming were studied to determine the capability of a Wetland Habitat Value (WHV) model to predict waterfowl use. While the size of most wetlands was less than expected by pre-construction

plans, the WHV model was able to accurately predict use of wetlands by migrating Canada geese, dabbling ducks, and diving ducks. Authors concluded that WHV models may be useful for estimating lost waterfowl habitat functions, but caution should be exercised not to overestimate post-construction wetland size and habitat availability.

McLeod, M., R. Reed, and L. D. Wike. 2000. Elevation, competition control, and species affect bottomland forest restoration. *Wetlands* 20:162-168.

Analysis of the effects of planting elevation and early successional vegetation control on growth and survival of six species of bottomland hardwood tree seedlings (bald cypress, water tupelo, willow oak, Nuttall oak, overcup oak, and cherrybark oak). Survival among tree species differed but was not affected by any of the vegetation competition control measures (mowing or herbicide application). However, growth and survival did vary with planting elevation: bald cypress and water tupelo survival and height were greatest at lower elevations; height and survival of cherrybark oak and willow oak were greatest at higher elevations; and overcup oak and Nuttall oak were not affected by elevation. Thus, whereas controlling herbaceous vegetation did not affect survival or growth, relative planting elevation was important because of site flooding and variation among species in flood tolerances.

Melvin, S. L., and J. W. Webb Jr. 1999. Differences in the avian communities of natural and created *Spartina alterniflora* salt marshes. *Wetlands* 18:59-69.

Bird diversity within and among bird groups (shorebirds, sparrows, herons and egrets, and waterfowl) was lower in created salt marsh than in natural marshes studied on the Texas Gulf Coast. Lower bird diversity was attributed to lower vegetation diversity and structure in created marsh than in natural marshes.

Metzker, K. D., and W. J. Mitsch. 1997. Modelling self-design of the aquatic community in a newly created freshwater wetland. *Ecological Modelling* 100:61-86.

A simulation model was constructed to predict the development of a fish community in a recently constructed freshwater marsh in Ohio. Modelled interactions included intra- and interspecific competition, predation, feeding, reproduction, fish effects on system abiotic components, and mortality. The fish community underwent several major changes in structure during the first four years of the simulation before establishing a stable state with a high-biomass population dominated by carp. The results indicated that the fish community in wetlands had a strong self-design trajectory, tending toward almost complete dominance by carp unless typical wetland environmental conditions were significantly altered.

Mitsch, W. J., A. van der Valk, and E. Jaworski. 1994. Wetland restoration at a former Nike missile base in the Great Lakes Basin. *Restoration Ecology* 2:31-42.

Restoration alternatives were evaluated at a former military base adjacent to the lower Detroit River, Michigan. Construction of wetlands resembling conditions before establishment of the military base was recommended for its low maintenance and opportunity for research on wetland design and construction in protected bays in the Great Lakes region.

Mitsch, W. J., and R. F. Wilson. 1996. Improving the success of wetland creation and restoration with know-how, time, and self-design. *Ecological Applications* 6:77-83.

A review of the literature available on the success of mitigation wetlands to replace lost wetland function revealed a high rate of failure due to problems with mitigation wetland construction, limited permit requirements, poor monitoring and follow-up, and lack of mitigation project implementation. To improve success of compensatory mitigation projects, three primary concepts were provided and discussed: (1) improve understanding of wetland function, (2) allow mitigation wetlands sufficient time to develop, and (3) allow natural processes to "self-design" the newly established wetland system. Recommended time scales for judging success of wetland establishment projects were 15-20 years for freshwater emergent wetlands and 50 years for some tidal salt marshes. Predictive modeling based on these time scales may be useful in projecting success of wetland mitigation projects.

Montgomery, J. A. 2000. The use of natural resource information in wetland ecosystem creation and restoration. *Ecological Restoration* 18:45-50.

Author discussed the need for wetland restoration and creation practitioners to communicate effectively with their colleagues in other disciplines. He emphasized the need for communication between earth scientists and biological scientists in wetland restoration and creation. Forthcoming compilation of papers addressing this need (*Use of Natural Resource Information in Wetland Ecosystem Creation and Restoration*) was discussed.

Munro, J. W. 1991. Wetland restoration in the mitigation context. *Restoration and Management Notes* 9: 80-86.

Author provided recommendations for improvements to wetland mitigation requirements, regulations, and guidelines.

Naugle, D. E., K. F. Higgins, M. E. Estey, R. R. Johnson, and S. M. Nusser. 2000. Local and landscape-level factors influencing black tern habitat suitability. *Journal of Wildlife Management* 64:253-260.

Local and landscape factors affecting habitat suitability for black terns were evaluated in 834 randomly selected wetlands in eastern South Dakota. Significant variables associated with black tern use included wetland area, total semipermanent wetland area within the wetland, and grassland area in the surrounding upland matrix. Black tern use was associated with large wetland basins located in high-density wetland complexes. Black terns typically occurred in wetlands within landscapes when less than 50 percent of upland grasslands were tilled. This illustrates the importance of including entire landscapes in habitat assessments. Future wetland conservation efforts should maintain the integrity of entire prairie landscapes in addition to individual wetland attributes.

Naugle, D. E., K. F. Higgins, S. M. Nusser, and W. C. Johnson. 1999. Scale-dependent habitat use in three species of prairie wetland birds. *Landscape Ecology* 14:267-276.

Study examined the effect of scale on habitat use of prairie wetlands by pied-billed grebes, yellow-headed blackbirds, and black terns in South Dakota. Whereas occurrences of pied-billed grebes and yellow-headed blackbirds were influenced by local wetland conditions and characteristics independent of landscape patterns, habitat use by black terns was related to features in the surrounding landscape. Yellow-headed blackbirds used both large and small wetlands, while pied-billed grebes exhibited area sensitivity by using only larger basins. Results indicated the need to consider entire landscapes, rather than individual patches, in determining habitat suitability for wide-ranging species such as the black tern.

Newman, J. M., and J. C. Clausen. 1997. Seasonal effectiveness of a constructed wetland for processing milkhouse wastewater. *Wetlands* 17:375-382.

Study assessed the effectiveness of the wetland in reducing nutrients, five-day biochemical oxygen demand, bacteria, total suspended solids, and fecal coliform bacteria in effluent from a milkhouse in central Connecticut. While the wetland was effective in partially meeting these objectives, preliminary indications were that the treatment of wastewater did not meet design standards, especially in winter when biological activity was reduced.

Northern Prairie Science Center and Midcontinent Ecological Science Center. 1996. Wetland restoration bibliography. Jamestown, ND: Northern Prairie

Wildlife Research Center Home Page. <http://www.npwrc.usgs.gov/resource/literatr/wetresto/wetresto.htm> (Version 06JUL2000).

An annotated bibliographic database intended to provide scientists, managers, educational institutions (or students), and policymakers with ready access to current information on wetland restoration. A bibliography originally developed and provided by the USGS/BRD Midcontinent Ecological Science Center served as the foundation for this bibliography. USGS/BRD Northern Prairie Science Center developed a program for viewing and searching the bibliography on the Web and assumed responsibility for maintaining and updating the database.

Nuttle, T., and L. W. Burger Jr. 1996. Response of breeding bird communities to restoration of hardwood bottomlands. *Proceedings of the Annual Conference of the Southeastern Fish and Wildlife Agencies* 50: 228-236.

Much of the original hardwood bottomland in the Mississippi Alluvial Valley has been converted to crop lands. Land management agencies began restoring hardwood bottomland because of its importance to wildlife. Bird communities were studied in bottomland hardwood restoration plantings of age 0-4, 7-15, and 21-27 years and natural sawtimber stands (> 50 years in age) in the southern Delta region of Mississippi. Mean number of species (species richness) increased with stand age. Mean total abundance did not differ among age classes. Relative to bird communities of natural sawtimber forest at Yazoo National Wildlife Refuge and Delta National Forest, respectively, Morisita's index of similarity was 85.4% and 74.3% for 21- to 27-year-old plantations, 41.9% and 35.0% for 7- to 15-year-old plantations, and 4.6% and 2.6% for 0- to 4-year-old plantations. Plantations in the 21-27 and 7-15-year-old age classes supported a substantial portion of the potential forest bird community, but still lacked area-sensitive and certain late-successional species. Plantations in the youngest age class were dominated by two abundant species, red-winged blackbird and dickcissel. Nevertheless, young plantations provide temporary habitat for regionally declining grassland bird species. Authors suggested that management prescriptions that mimic natural succession such as mixed plantings or thinning might enhance the restoration effort and promote earlier colonization by birds requiring mature forests.

Oertel, B. 1997. Wildlife habitat and wetland restoration on former cropland. *Land and Water* 41:45-47.

A description of how a 55-acre wetland was restored in northern New York and the landowner's enthusiasm for the wildlife response. Although no quantitative data were presented, anecdotal evidence was provided for substantial increases in wetland-associated wildlife use of the area.

Padgett, D. J., and G. E. Crow. 1994. Foreign plant stock: Concerns for wetland mitigation. *Restoration and Management Notes* 12:168-171.

Paper discussed concerns and issues related to use of non-indigenous and nonlocal plant materials in wetland establishment projects. To maximize success of establishment projects, minimize impacts to native wetland species and genetic stocks through competition and genetic swamping, and address the ethical considerations of introducing new species to the flora of a region, the authors strongly emphasized the need to acquire plant materials from local genetic stocks. Observation of nearby natural wetlands should guide planning for species composition of constructed wetlands.

Phinn, S. R., D. A. Stow, and J. B. Zedler. 1996. Monitoring wetland habitat restoration in southern California using airborne multispectral video data. *Restoration Ecology* 4:412-422.

Use of high-spatial-resolution digital video imagery to detect patches of marsh vegetation in a restored coastal marsh in California was described. Data were used to assess restored wetland habitat conditions for the light-footed clapper rail. Preliminary field-checking results indicated that this approach was an accurate, noninvasive, and cost-effective means of providing ecological information for restoration monitoring in southern California wetlands.

Prescott, K. L., and I. K. Tsanis. 1997. Mass balance modelling and wetland restoration. *Ecological Engineering* 9:1-18.

Phosphorus and suspended solids loading to a Lake Ontario coastal marsh were studied through the use of mass balance models. The study was conducted to increase understanding of degraded ecosystems to enable successful restoration actions. The models predicted average concentrations well, but variations in field data were not discerned by the models. The majority of phosphorus and suspended solids loading were shown to be derived through resuspension of sediments, while other inputs included rural runoff and combined sewage outflows.

Reaves, R. P., and M. R. Croteau-Hartman. 1994. Biological aspects of restored and created wetlands. *Proceedings of the Indiana Academy of Science* 103:179-194.

Authors reviewed literature on the biological aspects of restored and created wetlands. In general, restored wetlands were more similar to natural wetlands than were created wetlands, and the biota of restored wetlands more closely resembled that of natural

wetlands. Following restoration of wetland hydrology, native aquatic plants returned to restored wetlands within one year. As restored wetlands develop, they were colonized by a variety of aquatic invertebrates and other animals. Use of restored wetlands was related to the size of the wetland and proximity to other wetland habitats. In most instances, restored wetlands exhibited biological characteristics of nearby, similar-sized natural wetlands within 10 years after restoration. Plant communities and other wetland attributes of created wetlands differed from natural or restored wetlands because of altered hydrology or different water sources (e.g., effluent from wastewater treatment facility).

Richardson, M. S., and R. C. Gatti. 1999. Prioritizing wetland restoration activity within a Wisconsin watershed using GIS modeling. *Journal of Soil and Water Conservation* 54:537-542.

A geographic information system was developed for a watershed in southern Wisconsin to locate drained wetlands and their owners and rank drained wetlands for restoration based on their potential to improve water quality. GIS data layers for soils, cropping management, topography, hydrology, and land cover were used to estimate potential eroded sediments entering streams. GIS was used to delineate sub-watersheds of each drained wetland basin, estimate the delivered sediments that could be trapped if the drained basin were restored, and rank the drained wetlands for restoration within strata of topographic contours.

Rossiter, J. A., and R. D. Crawford. 1981. Evaluation of constructed ponds as a means of replacing natural wetland habitat affected by highway projects in North Dakota. University of North Dakota, Department of Biology Report FHWA-ND-RD-(2)-79A. University of North Dakota, Grand Forks. 171 pp.

Waterbirds, aquatic plants, macroinvertebrates, water quality, and soils were monitored in 18 artificial wetlands created by landfill extraction for Interstate 29 expansion in 1976 and 1977. Density of breeding pairs of waterfowl in artificial wetlands was greater in 1979 (wet year) than in 1980 (dry year), but was lower than natural basins of similar size in both years. Differences were attributed to dispersion and density of vegetation, macroinvertebrate abundance, water quality, and wetland basin topography. Authors recommended that borrow areas be designed with maximum shoreline, gradual slopes, and variable bottom elevations.

Rossiter, J. A., and R. D. Crawford. 1986. Evaluation of constructed ponds as a means of replacing natural wetland habitat affected by highway projects in North Dakota - Phase II. University of North Dakota, Department of Biology Report FHWA-ND-RD(2)-81A. University of North Dakota, Grand Forks. 169 pp.

Waterbird use and the abundance and diversity of aquatic plants and invertebrates were surveyed in 20 constructed wetlands created by landfill extraction for Interstate 29 expansion between 1976 and 1980. Characteristics of constructed wetlands were compared with six nearby natural basins of similar size. Compared to natural basins, constructed wetlands had greater waterfowl density and number of plant taxa and reduced diversity and abundance of invertebrates. Wetland size was determined to be the most important factor affecting waterfowl pair density and duckling production. Authors recommended that borrow areas be designed with maximum shoreline, gradually sloping sides, topsoil replacement on the substrate, and variable bottom elevations.

Ruwaldt, J. J. Jr., L. D. Flake, and J. M. Gates. 1979. Waterfowl pair use of natural and man-made wetlands in South Dakota. *Journal of Wildlife Management* 43:375-383.

Spring waterfowl pair use of natural ponds and lakes, streams, stock ponds, and dugouts in South Dakota was examined in 1973-74. Semipermanent wetlands and stock ponds contained proportionally more pairs of most waterfowl species than other wetland categories. Lack of water due to drought conditions apparently decreased waterfowl use of other wetland types.

Saracco, J. E., and J. A. Collazo. 1999. Predation on artificial nests along three edge types in a North Carolina bottomland hardwood forest. *Wilson Bulletin* 111:541-549.

Study conducted in North Carolina bottomland hardwood forest compared predation rates on artificial bird nests in three edge types: forest-farm, forest-river, and transition zone between dominant forest types. Nest predation was higher in forest-farm edges than in other edge types.

Schneller-McDonald, K., L. S. Ischinger, and G. T. Auble. 1990. Wetland creation and restoration: Description and summary of the literature. U.S. Fish and Wildlife Service Biological Report 90. 198 pp.

An annotated bibliography containing 1,100 records of literature on the subject of wetland creation and restoration. This hard copy document was the companion to the Wetland Creation/Restoration database. Since this version was produced, the database has been updated by USGS (see above Northern Prairie Science Center and Midcontinent Ecological Science Center 1996).

Sewell, R. W., and K. F. Higgins. 1991. Floral and faunal colonization of restored wetlands in west-central Minnesota and northeastern South Dakota. Pages 103-133 in F. J. Webb, Jr., ed. *Proceedings of the Fourteenth Annual Conference on Wetlands Restoration and Creation*. Hillsborough Community College, Plant City, Florida.

One hundred fifty-six restored seasonal and semipermanent basins of 12 different ages were surveyed in three counties of northeast South Dakota and six counties in west-central Minnesota to determine trends in species abundance and richness of waterfowl, aquatic macroinvertebrates, fish, and hydrophytes. A large diversity of flora and fauna colonized wetlands as early as one year after restoration. Twelve species of waterfowl were observed in all age classes of the restored basins. Thirty-one taxa of macroinvertebrates occurred in restored basins, 12 of which were in age class 1 basins. Four fish species inhabited restored basins of all ages. An average of over 16 taxa of aquatic hydrophytes had coverage values of greater than or equal to 5% of the total wetland area in restored basins. This study demonstrated that wetland managers can expect extensive floral and faunal colonization of prairie wetlands within one year of restoration.

Shreffler, D. K., C. A. Simenstad, and R. M. Thom. 1990. Temporary residence by juvenile salmon in a restored estuarine wetland. *Canadian Journal of Fisheries and Aquatic Science* 47(11):2079-2084.

Use of a recently restored estuarine wetland in Washington by out-migrating juvenile Pacific salmon was studied. Mark/recapture data indicate that 0.06% of juvenile chum salmon and 0.59% of juvenile fall chinook salmon entered the wetland. Estimated residence times of individual salmon ranged from 1 to 43 days. Data revealed that the restored wetland provided habitat for temporary residence of migrating juvenile chum and fall chinook salmon. Comparisons to natural wetland systems were not feasible.

Shreffler, D. K., C. A. Simenstad, and R. M. Thom. 1992. Foraging by juvenile salmon in a restored wetland. *Estuaries* 15:204-213.

Paper evaluated the functional value of a restored estuarine wetland in Washington as a foraging area for juvenile chum salmon and fall chinook salmon during their spring seaward migrations. Fish foraged selectively, primarily on chironomid insects. A detritus-based food chain suggested that the restored wetland provided productive foraging habitat for migrating juvenile chum and fall chinook salmon during their early residency in the estuary.

Smith, J. W., and D. D. Humburg. 1990. Reclaiming Missouri's Wetlands. *Missouri Conservationist* 51:7-9.

Authors described Missouri's plan to protect, restore, and manage wetland habitats. Efforts on public and private lands were outlined.

Streever, W. J., D. L. Evans, and T. L. Crisman. 1995. Chironomidae (Diptera) and vegetation in a created wetland and implications for sampling. *Wetlands* 15:285-289.

Distribution of Chironomids and emergent vegetation was examined in a created freshwater herbaceous wetland in central Florida. Three of the five common genera were more abundant in areas with greater than 50% herbaceous cover than areas with reduced vegetation. Samples from areas with greater than 80% vegetation cover showed greater abundance of all five common genera. Results indicated a strong association of benthic invertebrate communities with wetland vegetation.

Tsihrintzis, V. A., G. M. Vasarhelyi, and J. Lipa. 1995. Multiobjective approaches in freshwater wetland restoration and design. *Water International* 20:98-105.

Authors described a riparian corridor and freshwater wetland designed to meet California environmental requirements associated with land development actions. The project was designed to provide three functions: (1) flood control for existing and proposed developments, (2) urban stormwater runoff treatment, and (3) freshwater habitat for fish and wildlife. The project emphasized hydraulic analysis and design, biotic design, environmental function and effectiveness, management, operation, monitoring and maintenance, and project permit requirements.

Twedt, D. J., and J. Portwood. 1997. Bottomland hardwood reforestation for Neotropical migratory birds: Are we missing the forest for the trees? *Wildlife Society Bulletin* 25:647-652.

Breeding birds were studied on recently reforested bottomland hardwood sites in the Lower Mississippi River Alluvial Valley. Thirty-six avian species held breeding territories in cottonwood plantings aged 5-7 years ( $n = 12$ ). Conversely, on oak plantings aged 4-6 years ( $n = 3$ ), only nine bird species held breeding territories and most were grassland species. Thus, fast-growing species act as catalysts for the colonization of these emerging forests by Neotropical migratory birds. When reforesting agricultural sites, planting fast-growing tree species, alone or in concert with heavy-seeded species, represents a superior alternative to monotypic plantings of oaks. Fast-growing trees can rapidly provide habitat for forest-breeding, Neotropical migratory birds and enhance forest diversity. Reforestation using fast-growing species on private lands provides quick financial return through harvest of pulpwood.

Twedt, D. J., and W. B. Uihlein. In press. Reforestation priorities for migratory land birds in the Mississippi Alluvial Valley. In *Ecology and management of bottomland hardwood systems: The state of our understanding*. L. H. Fredricksen, editor. Memphis, Tennessee.

Authors proposed a method for geographically prioritizing reforestation efforts in the Lower Mississippi Alluvial Valley (MAV) based on habitat needs of forest breeding landbirds. Priorities were based on three parameters: (1) distance to extant forest, (2) distance to contiguous forest patches between 1,012 and 40,000 ha in size, and (3) distance to forest cores with contiguous area less than 5,200 ha. Information on the proportion of forest cover and average size of forest patches within landscapes of 50,000, 150,000, and 200,000 ha also was considered and combined with the three distance parameters to yield a single raster using a weighting system that gave emphasis to existing forest cores, larger forest patches, and moderately forested landscapes. Spatially explicit reforestation priorities were used to simulate reforestation of 368,000 ha of the highest priority lands in the MAV. Bird Conservation Regions developed within the Partners in Flight MAV Bird Conservation Plan encompassed approximately 70% of the area with highest priority for reforestation. Lands enrolled in the Wetlands Reserve Program also contained a high proportion of lands with high reforestation priority.

Tydeman, C. 1981. The general value of man-made wetlands for wildlife in Europe. Pages 5-19 in *Wildlife on man-made wetlands*. Buckinghamshire, England.

This report reviewed artificial wetland types and their importance for conservation and wildlife in Europe. Types of artificial wetlands included ponds and scrapes, extractive industries (i.e., coal and clay pits, etc.), gravel extraction pits, incidental wetlands, lagoons, canals, and reservoirs. Garden ponds were especially important habitat for amphibians as breeding sites. Wetlands brought about by extractive industries were beneficial to waterfowl, plants, and insects. Canals were beneficial to aquatic plants, insects, and amphibians. The author concluded that artificial wetlands were as important and beneficial to conservation and wildlife as "natural" wetlands.

Valladares, L. F., J. Garrido, and B. Herrero. 1994. The annual cycle of the community of aquatic Coleoptera (Adephaga and Polyphaga) in a rehabilitated wetland pond: The Laguna de La Nava (Palencia, Spain). *Annales de limnologie* 30:209-220.

The aquatic Coleoptera community was characterized in a restored wetland in northern Spain. The aquatic beetle community in the restored basin corresponded to that of a medium- or large-sized wetland with abundant plant life, but recent in origin. A diverse community of Coleoptera developed in the rehabilitated wetland, but most species belonged to early successional groups or were ubiquitists. Further study may reveal further changes in the beetle community through time.

Vanrees-Siewert, K. L., and J. J. Dinsmore. 1996.

Influence of wetland age on bird use of restored wetlands in Iowa. *Wetlands* 16:577-582.

Restored prairie wetlands of varying ages were studied in northern Iowa to determine relationships between bird use and wetland age. Mean number of breeding bird species was greater in four-year-old wetlands than one-year old-wetlands. Mean number of all bird species, waterfowl species, and breeding waterfowl did not change with wetland age. Total and breeding bird species richness increased with percent cover of emergent vegetation. Waterfowl use (breeding and total) was influenced more by wetland size than vegetation, whereas total bird species richness and breeding bird species richness were influenced more by vegetation characteristics. Results indicated that waterfowl habitat was provided shortly after wetlands were restored, and total bird species richness increased with wetland age. Study illustrated the value of long-term restorations in supporting diverse bird communities in restored wetlands.

Wallace, P. M., D. M. Kent, and D. R. Rich. 1996.

Responses of wetland tree species to hydrology and soils. *Restoration Ecology* 4:33-39.

The flood tolerance of nine tree species common in Florida forested wetlands was examined by subjecting seedlings grown on various soil types to 11 months of continuous shallow inundation or moist soil conditions. Pond cypress, red maple, and pond pine seedlings suffered no mortality; pop ash, sweetgum, slash pine, and loblolly bay experienced low to moderate (1% to 24%) mortality; and swamp red bay suffered significant mortality (46%). Greatest growth occurred on moist organic soil, while least seedling growth occurred on stockpiled topsoil and inundated soils. Results suggested that red maple, pop ash, pond pine, pond cypress, and bald cypress can survive to at least one year under a broad range of hydrological and soil conditions. First year growth can be maximized by maintaining moist, but not inundated, soil conditions. Transfer of organic soils to restoration sites also will benefit seedling growth and survival.

Weinhold, C. E., and A. G. van der Valk. 1989. The impact of duration of drainage on seed banks of northern prairie wetlands. *Canadian Journal of Botany* 67:1878-1884.

An analysis of seed banks in 30 extant and 52 drained and cultivated prairie potholes (range, 5-70 years post-drainage) in Iowa, Minnesota, and North Dakota. Number of species in the seed bank declined from a mean of 12.3 in extant potholes to 2.1 in potholes drained 70 years ago. Seed density was 3,600 seeds/m<sup>2</sup> in extant potholes, 7,000 seeds/m<sup>2</sup> up to five years after drainage, but only 160 seeds/m<sup>2</sup> in potholes 70 years after drainage. About 60% of species present in seed banks of extant or recently drained wetlands were not detected in wetlands that had been drained > 20 years.

Weinstein, M. P., J. H. Balletto, J. M. Teal, and D. F.

Ludwig. 1997. Success criteria and adaptive management for a large-scale wetland restoration project.

*Wetlands Ecology and Management* 4:111-127.

Restoration trajectories and success criteria were developed for a 4,050-ha tidal salt marsh to be restored on Delaware Bay, New Jersey, to offset loss of finfish from operation of a local power plant. Objectives for the restoration included returning the natural hydroperiod and drainage configuration to diked salt hay land and brackish marsh dominated by *Phragmites australis*. Restoration success was monitored by measuring macrophyte production, vegetation composition, benthic algal production, and drainage features, including stream order, drainage density, channel length, bifurcation ratios and sinuosity. These parameters were combined into a single success index. Adaptive management thresholds and corrective measures were provided to guide the restoration process through time.

Weller, J. D. 1995. Restoration of a south Florida

forested wetland. *Ecological Engineering* 4:143-151.

A drained forested wetland in south Florida was restored by reestablishing pre-drainage hydrology and removing exotic vegetation (Brazilian pepper). These actions resulted in restoring wetland characteristics, including increased groundwater elevation and duration of surface water. Results ensured the conservation of 34 rare fern species and encouraged the return of 16 wetland bird species, eight fish species, six species of turtles, six species of snails, two frog species, and the American alligator.

Weller, M. W. 1990. Waterfowl management techniques for wetland enhancement, restoration, and creation useful in mitigation procedures. Pages 517-528 in J. A. Kusler and M. E. Kantula, eds. *Wetland creation and restoration: The status of the science*. Island Press, Washington, D.C.

Paper provided general concepts for enhancing waterfowl habitat in wetlands restored, enhanced, or created to meet mitigation requirements. Working with natural processes to maximize habitat quality was emphasized. Design considerations included geomorphology, landscape position, and habitat patch size and pattern. Wetland complexes should be emphasized; vegetation diversity and interspersions with water, and wetland configuration and edge also were emphasized. Contouring with earth-moving equipment may be used to create water depths associated with desired plant communities. Inputs of sediment and excess nutrients should be controlled on adjacent uplands and water control structures must be engineered to handle peak flows. Steps should be taken to control erosion and turbidity within managed wetland systems. Special needs of target wildlife species should be considered in managing wetlands. Seed bank and plant community may be managed through water level manipulation, herbivory, and fire. Specific examples of management of palustrine emergent wetlands, moist soil impoundments, tidal estuarine wetlands, and green-tree reservoirs were provided.

White, J. S., and S. E. Bayley. 1999. Restoration of a Canadian prairie wetland with agricultural and municipal wastewater. *Environmental Management* 24:25-37.

A 1,246-ha formerly drained northern prairie wetland was restored using municipal wastewater. Five years after restoration, the basin provided habitat for wildlife and increased abundance and species richness for target species. Fifty shorebird species, 44 waterfowl species, 15 raptor species, and 28 other new bird species returned to the marsh since restoration. Specific management actions were taken to further enhance wildlife habitat quality, such as water level manipulation and installation of artificial nesting structures.

Wilson, R. F., and W. L. Mitsch. 1996. Functional assessment of five wetlands constructed to mitigate wetland loss in Ohio, U.S.A. *Wetlands* 16:436-451.

Hydrology, soils, vegetation, wildlife use, and water quality measurements were taken in five created or restored wetlands in Ohio to evaluate their effectiveness in replacing lost wetland ecological function. Four of the five wetlands demonstrated medium to high ecosystem function success. While habitat structure was provided in replacement wetlands, wildlife use of restored/created wetlands appeared to be affected more by surrounding land use than within-wetland habitat structure.

Wilson, R. R., and D. J. Twedt. In press. Bottomland hardwood establishment and avian colonization of reforested sites in the Mississippi Alluvial Valley. In *Ecology and management of bottomland hardwood systems: The state of our understanding*. L. H. Fredricksen, editor. Memphis, Tennessee.

Bottomland hardwood establishment and avian colonization were evaluated in 120 reforested sites throughout the Lower Mississippi Alluvial Valley (MAV). Planted and naturally invading trees were generally slow to develop vertical cover, resulting in grassland bird species dominating the avian community for up to 15 years after planting. Because colonization by forest birds was dependent on tree height, the authors recommended inclusion of at least one fast-growing tree species in planting stock to encourage rapid avian colonization.

Wolf, R. B., L. C. Lee, and R. R. Sharitz. 1986. Wetland creation and restoration in the United States from 1970 to 1985: An annotated bibliography. *Wetlands* 6:1-88.

Annotated bibliography of publications on the topic of wetland creation and restoration in the United States.

Young, P. 1996. The "New Science" of Wetland Restoration. *Environmental Science and Technology* 30:292A-296A.

Authors discussed the complexity of creating wetlands that adequately replicate natural wetland functions. The importance of understanding how wetlands function and adequately establishing wetland hydrology in wetland construction work was emphasized. Several examples were presented to illustrate the complexity of wetland construction (San Diego Bay) and restoration (Florida Everglades) projects.

Zedler, J. B. 1987. Why it's so difficult to replace lost wetland functions. Pages 121-123 in J. Zelazny and J. S. Feierabend, eds. *Proceedings of a Conference - Increasing our Wetland Resources*. National Wildlife Federation - Corporate Conservation Council, Washington, D.C.

Author discussed challenges faced by wetland restoration practitioners. These included (1) differing views on wetland restoration goals, (2) complexity of original wetland systems, (3) inadequate understanding of long-term wetland development processes and how wetland components interact, (4) lack of background information on potential restoration sites, and (5) transient nature of plant and animal species. Authors concluded that long-term monitoring and research were needed to address these issues.

Zedler, J. B., G. D. Williams, and J. S. Desmond. 1997. Wetland mitigation: Can fishes distinguish between natural and constructed wetlands? *Fisheries* 22:26-28.

Fish communities in excavated tidal channels were compared with natural tidal channels in a southern California tidal wetland. Native fish colonized the excavated channels with densities higher than that measured in natural channels. Findings indicated that southern California coastal fishes did not discriminate between natural and constructed wetland channels.



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## Appendix II: An Annotated Bibliography for Wildlife Responses to the Conservation Reserve Program

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The following bibliography provides brief summaries of research products examining the effects of the Conservation Reserve Program and agricultural policies on wildlife and their habitats. The summaries below provide only general overviews; therefore, users are urged to review reports in their entirety to obtain a more thorough understanding of results and recommendations. Citations without annotations were not reviewed.

Allen, A. W. 1993. Wildlife habitat criteria in relation to future use of CRP lands. Pages 41-88 in *Proceedings of the Great Plains Agricultural Annual Meeting*, June 2-4, 1993. Rapid City, South Dakota.

Report, based on input solicited from state and federal biologists, identified strengths and weaknesses of the CRP as wildlife habitat. Information was presented on relationships between the CRP, specific conservation practices, spatial considerations, planning, and management. Need was identified for explicit definitions of CRP/wildlife objectives on regional and local scales.

Allen, A. W. 1994a. Regional and state perspectives on Conservation Reserve Program (CRP). U.S. Fish and Wildlife Service Federal Aid Report, National Biological Survey, National Ecology Research Center, Fort Collins, Colorado. 28 pp.

Literature review and information furnished by state and federal biologists on regional effects of CRP on wildlife in agricultural ecosystems. Needs of endemic grassland species and other wildlife species more traditionally associated with agricultural land use were compared. Recommendations included: (1) need for elevated involvement of state wildlife agencies in technical assistance to USDA agencies and contractees, (2) increased flexibility in conservation practices implemented, and (3) greater recognition of regional and local priorities.

Allen, A. W. 1994b. Conservation Reserve Program (CRP) contributions to avian habitat. U.S. Fish and Wildlife Service Federal Aid Report, National Biological Survey, National Ecology Research Center, Fort Collins, Colorado. 19 pp.

Summary of CRP contributions to distribution and quality of habitat for game and nongame birds associated with agricultural ecosystems. Report concentrates largely on species endemic to grassland ecosystems. Author discussed characteristics of CRP contracts with greatest potential benefits, landscape planning, and management recommendations.

Allen, A. W. 1994c. Wildlife benefits of the Conservation Reserve Program: a national perspective. Pages 18-20 in *When Conservation Reserve Program contracts expire: The policy options*. Soil and Water Conservation Society, Ankeny, Iowa.

The author provided a concise synopsis of the wildlife benefits of CRP. He attributed improved reproductive success and expanded distribution of several grassland bird species to the establishment of CRP grasslands. The article reported that nest success of upland-nesting waterfowl on CRP land was higher than on established waterfowl production areas. He discussed how the pattern of CRP land distribution within a watershed would influence wildlife. The author concluded that agricultural policies and environmental concerns can be compatible and result in public benefits on a national scale.

Allen, A. W. 1994d. Wildlife benefits of the Conservation Reserve Program: A national perspective. *Land and Water: Magazine of Natural Resources and Restoration* 38:23-25.

See Allen (1994c). Above article published by magazine to reach wider audience.

Allen, A. W. 1995a. Agroforestry and wildlife: alternatives and opportunities. Pages 67-73 in W. J. Rietveld, editor. *Proceedings of Agroforestry, Sustainable Agriculture Symposium*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-GTR-261.

Author presented spatial design considerations of tree-dominated cover types within agricultural ecosystems to benefit selected species of wildlife. He discussed potential negative effects of tree/shrub-dominated covers to endemic avian grassland species.

Allen, A. W. 1995b. Agricultural ecosystems. Pages 423-426 in E. T. LaRoe, G. S. Farris, E. E. Puckett, P. D. Doran, and M. J. Mac, editors. *Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems*. U.S. Department of the Interior, National Biological Service, Washington, D.C.

Author summarized historical effects of agricultural production on quality and distribution of wildlife habitats. He presented preliminary results of multi-state monitoring effort to describe grassland characteristics in undisturbed CRP fields in the southern Plains and Midwest. He discussed potential benefits of CRP for wildlife populations associated with agriculturally dominated landscapes.

Allen, A. W., Y. K. Bernal, and R. J. Moulton. 1996. *Pine plantations and wildlife in the southeastern United States: An assessment of impacts and opportunities*. U.S. Department of Interior, National Biological Service. Information and Technology Report 3. 32 pp.

Report documented the nation's growing dependence on southeastern forest products and the major role that private lands will play in provision of timber resources in future decades. Nontimber-related financial investment, recreation, and aesthetic considerations increasingly define acceptable management goals for owners of nonindustrial private forestland (NIPF). Wildlife was the principal factor affecting management on a growing number of privately owned forest lands. Author projected that within the next 50 years, the area of even-aged pine plantations, including CRP, on southeastern NIPF lands will exceed 20 million acres. Silvicultural

prescriptions applied to forestlands will influence wildlife habitat quality within as well as across stand boundaries and may potentially influence habitat distribution on a landscape scale. Various alternatives in physical design, location, and subsequent management of pine plantations were presented to mitigate negative effects of even-aged forest management on wildlife.

Allen, A. W., B. S. Cade, and M. W. Vandever. In press. Effects of emergency haying on vegetative characteristics within selected Conservation Reserve Program fields in the northern Great Plains. *Journal of Soil and Water Conservation*. In press.

Study compared vegetative characteristics of undisturbed and hayed CRP fields in North and South Dakota in 1999. Fields used in the study were of the same age and planted with similar mixes of cool-season, introduced grasses and forbs. Emergency haying had little long-term effect on vegetation height/density, percent cover of live grass, or forb cover when compared to undisturbed fields. The presence of legumes (primarily alfalfa) increased in response to haying, whereas abundance of noxious weeds (primarily Canada thistle) decreased. Implications for long-term management of CRP grasslands to meet avian habitat requirements were discussed.

Allen, K. 1990. Reflections on the past, challenges for the future: An examination of U.S. agricultural policy goals. Pages 3-23 in K. Allen, editor. *Agricultural policies in a new decade*. Resources for the future. Washington, D.C.

The development of agricultural policy has become a process of mutual accommodation with large numbers of narrow provisions being fitted together to become broad-based legislation often containing inconsistencies and few clues to real goals of policy. Agricultural policy is forced to address many more issues than farm prices and incomes. Food, fiber, trade, environmental health, rural macroeconomic, and foreign policies have all become important constituents in formulation of agricultural policies. Main objective of farm groups remains price and income support, market stability. Overall goals have broadened in response to a political environment in which there is an increasing awareness among nonfarm interests that agricultural programs have been partly responsible for detrimental effects on the environment.

Consumer interests will become increasingly important to the largely urban Congress. Demographic changes in population will continue to cause changes in consumers' tastes and preferences. Concerns about chemical residues in foods and their injection into the environment are a major issue and will continue to be so. The public wants to provide support for farmers but are increasingly disenchanted with subsidies that go largely to the largest, wealthiest farmers. Rural economies: Farming and agricultural service industries together contributed only about 8% of the personal income in nonmetropolitan areas in 1986. Raising farm prices for select agricultural commodities is an inefficient way to promote rural economic activity. Economically diversified rural

communities can offer greater employment opportunities to farmers who wish to continue farming but who also have difficulties meeting financial commitments. Small, marginal changes can yield significant results in the long-run. Long-term goal of agricultural policies should be promotion of a healthy, competitive, and diverse agricultural sector and viable, diverse rural communities.

Allen, P., D. Van Dusen, J. Lundy, and S. Gliessman. 1991. Integrating social, environmental, and economic issues in sustainable agriculture. *American Journal of Alternative Agriculture* 6:34-39.

Review of popular definitions of sustainable agriculture indicated that focus was primarily on farm-level resource conservation and profitability as main components of sustainability. Authors proposed an expanded understanding of sustainability that focuses on entire food and agricultural system at global level and includes environmental soundness, economic viability, as well as social equity.

Altieri, M. A. 1990. How best can we use biodiversity in agroecosystems? *Outlook on Agriculture* 20:15-23.

Anderson, R. E. 1991. Wisconsin wetlands restored. *Soil and Water Conservation News* 12:14.

Author described wetland restorations in CRP fields in Wisconsin. In a two-year period, 110 wetlands were restored on CRP lands. Author reported wildlife occurrences on the sites.

Anderson, W. L., and L. M. David. 1992. Results of the 1991-1992 Illinois quail hunter survey. Illinois Department of Conservation, Division of Wildlife Resources Administrative Report. Chicago. 17 pp. + appendices.

Anderson, W. L., and L. M. David. 1992. Results of the 1991-1992 Illinois pheasant hunter survey. Illinois Department of Conservation, Division of Wildlife Resources Administrative Report. Chicago. 16 pp. + appendices.

Angelstram, P. 1986. Predation on ground-nesting birds' nests in relation to predator densities and habitat edge. *Oikos* 47: 365-373.

General discussion of how predators utilize different habitats. As the size of habitat areas decreases, the influences of surrounding cover become increasingly important. Since relative amount of edge increases as patch size decreases, the predation rate should be inversely related to the size of the patch. High densities of generalist

predators are often a consequence of human activities (agriculture). Edges in more productive habitats will experience greater predation than edges in less productive habitats

Angermeier, P. L., and J. R. Karr. 1994. Biological integrity versus biological diversity as policy directives. *Bioscience* 44:690-697.

Biological integrity refers to a system's wholeness, including presence of all appropriate elements and processes at appropriate rates. Diversity is collective property of system elements. Unlike diversity, which can be expressed as the number of kinds of items, integrity refers to condition. High integrity reflects natural evolutionary and biogeographic processes. The value of many artificial, human-generated landscapes, such as agricultural landscapes, depends on naturally evolved elements and processes (e.g., nitrogen-fixing bacteria and soil formation). Attempts to reconstruct desirable biotic conditions must proceed with the best information currently available. Ineffective policy that emphasizes piecemeal conservation rather than comprehensive protection has been unsuccessful. Focus of policy formulation should be protection of processes that generate and maintain all elements. Policy effectiveness also could be improved by shifting focus from populations and species to landscapes.

Ball, I. J., R. J. Eng, and S. K. Ball. 1995. Population density and productivity of ducks on large grassland tracts in north-central Montana. *Wildlife Society Bulletin* 23:767-773.

Analysis of variation in duck productivity associated with block size and effects of the presence of red fox versus coyotes. Productivity of dabbling ducks on large grassland tracts with relatively low populations of predators was higher than recorded where habitat fragmentation and high populations of predators supported by alterations in habitat were more severe.

Attempts to improve nest success at an inappropriately small scale may be counterproductive if hens and predators are attracted to same limited area. Increasing surface water area in areas where rates of nest success are low, attracts pairs to situations where mortality exceeds recruitment. Due to foraging strategies and prey preferences, productivity of dabbling ducks can be expected to be higher in large grassland tracts where coyotes are primary predator. More fragmented habitats where red fox is dominant predator can be expected to have lower waterfowl productivity.

Baker, B. 2000. Farm Bill environmental program may threaten native prairie habitat. *Bioscience* 50:400.

Description of potential detrimental consequences of CRP due to extensive use of crested wheatgrass in Northwest and failure of USDA conservation provisions to prohibit sodbusting. Although crested wheatgrass furnishes erosion control and was recommended for establishment in a drought period, negative aspects of the planting include establishment of monocultures, limited value to wildlife, and invasion of the species into remaining stands of native

prairie. Current USDA policies advocate planting of native grasses. Farmers who intend to plant invasive species are now less likely to be accepted or have contracts renewed in CRP. Currently, there are no restrictions on breaking out native grasslands for crop production while enrolling existing cropland into CRP. The landowner's incentive for putting grassland into crops presumably is better production in newly tilled land. Issue appears to be restricted to northern Great Plains where cropland acres increased by 708,000 acres during first 10 years of CRP.

Barbarika, A., T. Osborn, and R. Heimlich. 1994. Using an environmental index in the Conservation Reserve Program. Pages 118-133 in *Proceedings of the NCT-163 Post Conservation Reserve Program Land Use Conference*, January 10-11, 1994. Denver, Colorado.

Barker, J. R., G. A. Baumgarder, D. P. Turner, and J. J. Lee. 1996. Carbon dynamics of the Conservation and Wetland Reserve Programs. *Journal of Soil and Water Conservation* 51:340-346.

Analysis of Conservation and Wetland Reserve Programs to quantify carbon (C) dynamics of cropland conversion to grassland or forestland. Cropland converted to forestland gained C at a rate about 7-times greater than cropland converted to grassland. Maintaining existing CRP grassland will provide substantial C sequestration on a national scale due to large area enrolled in long-term set-aside.

Barnes, T. G., L. A. Madison, J. D. Sole, and M. J. Lacki. 1995. An assessment of habitat quality for northern bobwhite in tall fescue-dominated fields. *Wildlife Society Bulletin* 23:231-237.

Evaluation of tall fescue (*Festuca arundinacea*) fields in Kentucky. Fields characterized by dense vegetation, little bare ground, and low plant species diversity. Tall fescue characterized as marginal habitat for bobwhite quail due to unsuitable vegetation structure, floristic composition, and insufficient food. Tall fescue is grown extensively for stock feed, turf, and conservation purposes. It is an excellent pasture grass and the dominant grass seeded in most southeastern CRP fields. Aggressive domination of fields by tall fescue may reduce plant species diversity resulting in lower quality of habitat. Infection of endophytic fungus (*Acremonium coenophialum*) may result in fescue toxicosis, reproductive disorders in mammals, and reduced fertility and hatching success in quail have been documented.

Basore, N. S., L. B. Best, and J. B. Wooley. 1986. Bird nesting in Iowa no-tillage and tilled cropland. *Journal of Wildlife Management* 50:19-28.

Analysis of bird nesting in Iowa no-tillage and tilled croplands. Bird densities greater in no-till fields than in tilled fields. Vegetation residue was important for attracting birds to no-till fields; nest destruction by farming implements in no-till fields was infrequent compared to tilled fields. No-till fields had nest density of 36 nests/100 ha compared to four nests/100 ha in tilled fields. Nests in tilled fields were in locations where there was residual vegetation.

Beauchamp, W. D., R. R. Koford, T. D. Nudds, R. G. Clark, and D. H. Johnson. 1996. Long-term declines in nest success of prairie ducks. *Journal of Wildlife Management* 60:247-257.

Analysis of mallard, northern pintail, gadwall, blue-winged teal, and northern shoveler nesting success in Prairie Pothole Region of Canada and United States, 1935-1992. Nest success was higher in late than in early nesting species but declined in all species at similar rate. Time explained only 10% of variation in nest success; precipitation did not account for additional explained variation. Population declines in mallard, northern pintail, and blue-winged teal coincide with temporal declines in nest success.

Berg, N. A. 1994. The genesis of the CRP. Part 1: evolution of the CRP. Pages 7-12 in *When Conservation Reserve Program contracts expire: The policy options*. Soil and Water Conservation Society, Ankeny, Iowa.

History of land set-aside programs leading up to creation of CRP. Major factors contributing to passage of 1985 Farm Bill were (1) need for revamping of agricultural policy, (2) spiraling farm program costs, (3) poor farm economy, (4) destructiveness of existing agricultural policies, and (5) recognition of nonagricultural stakeholders.

Berner, A. H. 1984. Federal land retirement program: A land management albatross. *Transactions of the North American Wildlife and Natural Resources Conference* 49:118-130.

Acreage reduction portion of Soil Bank and Feed Grain Program did not require seeding of grass-legumes on retired acres. Annual programs emphasized administrative flexibility in commodity control to the detriment of soil and wildlife conservation. Most acres in these programs were fallow or disked by the end of July to the detriment of both game and nongame species. Agricultural Stabilization and Conservation Service (ASCS) regulations required that most fields be planted late (after June 15) and covers be destroyed by mowing, disking, or plowing before grain matured (usually mid-July). Before 1985, land retirement programs were narrow in scope, dealing exclusively with controlling production of domestic commodities. Policies tended to encourage conversion of

noncropland to cropland even if those lands were highly erodible. Additionally, uncertainties about program structure made planning difficult, so farmers tended to prepare all acres for planting.

Author concluded that annual land retirement programs (1961-1983) aggravated soil erosion and wildlife habitat problems and encouraged unwise use of land. To reduce soil erosion and provide secure habitat for wildlife associated with farmland landscapes, he recommended that set-aside program provide long-term retirement options and require seeding with perennial grass-legume mixture.

Berner, A. H. 1988. Federal pheasants - impact of federal agricultural programs on pheasant habitat, 1934-1985. *In* Pheasants: Symptoms of wildlife problems on agricultural lands.

Review of pheasant responses to federal agricultural programs. Federal agricultural programs designed to assist farmers through cropland diversion and deficiency payment programs significantly impacted the amount and quality of pheasant habitat between 1934 and 1985. Pheasants responded positively to multi-year cropland diversion programs, but they responded negatively to annual cropland set-aside programs that allowed poor cover management and required periodic disturbance. Potential of annual set-aside programs such as the Feed Grain (FGP) and Wheat Production Programs (WHP) for providing safe nesting and brood-rearing cover for pheasants was limited by early destruction of cover before seed head development. In Minnesota, set-aside programs had a pronounced negative effect on pheasants. Under these programs a majority of fields were fallowed or lightly seeded to small grain in early June and destroyed by July 15. Nesting cover was absent, poor, or fair on about 80% of set-aside lands and good to excellent on only about 20% of set-aside lands. Hunting cover and winter cover were rated about 4.4% fair, 7.4% good, and 2.8% excellent. Proper management of these lands could greatly benefit game and nongame populations.

Berner, A. H. 1989. The 1985 Farm Act and its implications for wildlife. Pages 437-465 in 1988/1989 Audubon wildlife report. National Audubon Society, New York.

Changes in land use and agricultural production significantly affected wildlife inhabiting agricultural landscapes between 1934 and 1985. Specialization and intensification of agricultural production were responsible for severe declines in many populations of wildlife. Federal commodity programs contributed to much of the decline in habitat quality and availability. The 1934 Cropland Adjustment Act was the first retirement program with the purpose of stabilizing the market and farm economy. Planting of cover on retired acres was not required. The 1936 Agriculture Conservation Program created SCS and ASCS and required farmers to plant grass or grass-legume cover on set-aside lands. Soil Bank established in 1956 provided annual to 10-year set-aside (Conservation Reserve) options.

Wildlife benefits of set-asides were limited by the short duration of contracts, frequency and timing of disturbances, wide variety of agricultural management practices implemented, and lack of technical guidance. Additionally, local guidance was left to the state or county committees comprised of area farmers which, many times, resulted in environmentally questionable management practices. For example, many committees allowed late seeding of cover crops or required no plant cover and permitted or required destruction of established cover in the fall.

During the period of 1956-1987, low prices for crops precipitated by overproduction resulted in low farm income. Subsidy programs were implemented to stabilize farm economy and increase farm income. USDA subsidy programs produced conflicting results, i.e., conversion of noncropland to cropland that contributed to an increase in the crop base and higher program costs.

ARP (acreage reduction programs) paid farmers to annually idle land to reduce production of commodity crops. Regulations that once required reducing soil loss to "T," now allow highly erodible croplands to be farmed under an approved conservation plan that addresses soil loss. USDA predicted that crop surpluses will exist at least through 2000. More than 20 million acres/yr were expected to be retired in ARP. Because ARP agreements were annual, farmers were unwilling to pay to seed perennial grass-legume cover crops. ASCS committees generally opted to maintain maximum flexibility in establishing cover requirement, crop seeding dates, and rates and dates of cover destruction with minimal natural resource benefits.

Pheasant populations substantially increased when ARP acres were planted early to annual cover crops (typically small grains) and maintained to multi-year covers. However, ARP encouraged some practices that were detrimental to wildlife. Pheasant production in Minnesota was 30% lower in years with an ARP compared to years without the program. Author suggested that negative impacts could be reversed if set-aside acres were seeded to annual cover crop (small grains) and not disturbed for 90 days. In areas where winter cover may be critical, ARP should be seeded to cover crop such as forage sorghum and left undisturbed throughout winter. Cover for three or more years would provide maximum benefits.

Berner, A. H. 1994. Wildlife and federal cropland retirement programs. Pages 70-75 in *When Conservation Reserve Program contracts expire: The policy options*. Soil and Water Conservation Society, Ankeny, Iowa.

Review of studies of wildlife responses to cropland retirement programs from 1956 to 1984. Author recommended that future cropland retirement programs have the following features: (1) adequate technical assistance and cost share, (2) long-term retirement option and management assistance for environmentally sensitive areas, (3) multi-year (> 3 yrs) set-aside that emphasizes crop rotation and forage reserve objectives, (4) annual set-asides that protect soil, water, and wildlife, and (5) broader public representation of county and state technical committees. Recommended program would be decoupled from commodity control with incentives for sound land management (i.e., stewardship payments).

Berthelsen, P. S. 1989. Value of the Conservation Reserve Program to birds in the Texas southern High Plains. M.S. thesis. Texas Tech University, Lubbock. 106 pp.

Author stated that the greatest potential benefit of the CRP to wildlife in the southern High Plains was provision of secure, high quality nesting and winter cover for avian species. Bird species composition on CRP lands was represented primarily by two to three dominant species. Seven of 13 species observed on CRP lands were considered migrants or winter residents. Fields of blue grama/Kleingrass (BG/K) had the greatest avian winter densities, avian biomass estimates, nest densities, number of birds observed, and winter cover quality for pheasants. Compared to BG/K, bird use was reduced in blue grama/side-oats grama and blue grama/plains bluestem mixes.

Nest success on CRP lands averaged 22%; no apparent difference in nest success between CRP cover types. Earlier initiation of pheasant nests in CRP compared to surrounding area attributed to increased availability of nesting habitat, favorable weather, or hens entering breeding season in good physiological condition. CRP lands enabled nesting pheasants to disperse from margins of playa wetlands that were often flooded. Approximately one-third of fields evaluated were hayed or mowed for weed control resulting in minimal to no value as beneficial habitat for upland nesting birds. Mowing of CRP fields for weed control was unnecessary. As stands aged, grasses out-competed forbs. Weed control further reduced vegetative diversity in CRP fields.

Berthelsen, P. S., and L. M. Smith. 1995. Nongame bird nesting on CRP lands in the Texas southern High Plains. *Journal of Soil and Water Conservation* 1995:672-675.

Authors determined nongame bird species composition, nest density, and nesting success in CRP fields planted to the three most common grass mixtures. The fields were planted in 1987 and field work was conducted in 1988 and 1989. The average nest densities of the birds found using the CRP fields decreased or remained similar between 1988 and 1989. Overall nest success was 40.5 percent. Authors speculated that as CRP cover types aged, their value as nongame bird habitat may decline. However, they concluded that increases in CRP fields in the southern High Plains were improving habitat for nongame birds, since few of these species nest in cropland.

Berthelsen, P. S., L. M. Smith, and C. L. Coffman. 1989. CRP land and game bird production in the Texas High Plains. *Journal of Soil and Water Conservation* 44:504-507.

Determination of cover types, acreages, establishment success, and establishment costs for CP1, CP2, CP4, CP10, and CP12 in southern High Plains of Texas. Estimated that annual production

for selected practices was 174,000 pheasant chicks and 1,400 ducklings. Noted that CRP benefits for waterfowl were limited by availability of water.

Berthelsen, P. S., L. M. Smith, and R. R. George. 1990. Ring-necked pheasant nesting ecology and production on CRP lands in the Texas southern High Plains. *Proceedings of the North American Wildlife and Natural Resources Conference* 55:46-56.

Study conducted in southern High Plains of Texas in 1988-1989 compared pheasant nest success on CRP and cropland, estimated production and recruitment rates for pheasants in selected CRP grass mixes (blue grama/side-oats grama, blue grama/Kleingrass, and blue grama/plains bluestem), and provided management recommendations. Annual estimates of pheasant nest density, nest success, clutch size, and egg hatchability, and vegetative structure were provided by seeding mixture. Blue grama/Kleingrass mixture had greatest avian nest density, and pheasant nest density, success, and productivity. Wildlife benefits were reduced on one-third of study sites that were hayed.

Best, L. B., H. Campa III, K. E. Kemp, R. J. Robel, M. R. Ryan, J. A. Savidge, H. P. Weeks Jr., S. R. Winterstein. 1998. Avian abundance in CRP and crop fields during winter months in the Midwest. *American Midland Naturalist*. 139:311-324.

Avian abundance and nesting success were compared in Conservation Reserve Program (CP1 and CP2) and rowcrop fields in six midwestern states (Indiana, Iowa, Kansas, Michigan, Missouri, and Nebraska), 1991-1995. Number of species was similar in two habitats but abundance was 1.4 to 10.5 times greater in CRP fields. Additionally, number of nesting species was > 3 times greater and nest density was 13.5 times greater in CRP fields. Authors concluded that CRP provided many benefits for grassland birds, including several species of special concern.

Best, L. B., H. Campa III, K. E. Kemp, R. J. Robel, M. R. Ryan, J. A. Savidge, H. P. Weeks Jr., and S. R. Winterstein. 1997. Bird abundance and nesting in CRP fields and cropland in the Midwest: A regional approach. *Wildlife Society Bulletin* 25:864-877.

Comparison of abundance and nesting success of avian species in CRP and rowcrop fields over five years (91-95) in six Midwest states (Indiana, Kansas, Missouri, Michigan, Nebraska, and Iowa). Bird abundance 1.4 to 10.5 times greater in CRP than rowcrop. Nests of 33 bird species found in CRP with only 10 species in rowcrops; number of nests found 13.5 times greater in CRP. Nest success was 40% in CRP. Nest success in rowcrops similar to that of in CRP, but total number of nests found in rowcrop was 7.4% of that in CRP. Predation was greatest cause of nest failure. Long-term farm set-aside programs that establish perennial grass cover

provided many benefits for grassland birds, including several species for which conservation is a great concern. Authors recommended further investigation of species-specific habitat requirements in relation to planting, management, and spatial configuration of CRP.

Best, L. B., K. E. Freemark, J. J. Dinsmore, and M. Camp. 1993. A review and synthesis of habitat use by breeding birds in agricultural landscapes of Iowa. *American Midland Naturalist* 134:1-29.

Papcr reviewed species composition, abundance, and nesting status of 144 birds in 20 habitats characteristic of Iowa's agricultural landscape. Density highest in linear habitats (railroad right-of-ways, wooded fencerows, and shelterbelts), lowest in rowcrop and small grain fields, and intermediate in natural habitats (upland and floodplain forest, marsh, and prairie). Species diversity predicted to increase with habitat diversity in landscape.

Best, L. B., R. C. Whitmore, and G. M. Booth. 1990. Use of cornfields by birds during the breeding season: The importance of edge habitat. *American Midland Naturalist* 123:84-99.

Study of breeding bird use of Iowa cornfields. A significant edge effect was detected with more bird species and about five-times more birds found in the perimeters of cornfields than in the centers of fields. Bird abundance in cornfields was greater along wooded edges than along herbaceous edges, suggesting that bird use of cornfields was influenced by adjacent habitat type. Authors concluded that shifts in land use practices resulting in increased field size and elimination of woody vegetation from edge habitats will affect both richness and abundance of avifauna associated with agricultural ecosystems.

Bjerke, K. 1991. An overview of the Agricultural Resources Conservation Program. Pages 7-10 in L. A. Joyce, J. E. Mitchell, and M. D. Skold, editors. *The Conservation Reserve - yesterday, today, and tomorrow*. U.S. Department of Agriculture, U.S. Department of Agriculture, Forest Service, General Technical Report RM-203. 64 pp.

Paper described three new features in the Food, Agriculture, Conservation, and Trade Act of 1990: Wetland Reserve Program, Agricultural Water Quality Incentives, and Environmental Easement Program. CRP accomplishments (1985-1990) were summarized in terms of acreage by conservation practice and economic benefits from improved water quality (\$1.3-3.9 billion), recreation (\$1.9-3.1 billion), and timber products (\$3.3 billion).

Boatman, N. D., and N. W. Sotherton. 1988. The agronomic consequences and costs of managing field margins for game and wildlife conservation. *Aspects of Applied Biology* 17:47-56.

Removal of weeds, either through herbicides or mowing, decreases insect density and diversity associated with cereal crops. Increased use of herbicide in recent decades has removed host plants of many insects, and more recently, the use of insecticides has caused direct mortality of other species of insects. Consequently, there has been a reduction in the numbers and diversity of insect species which are the primary forage of early age class chicks of upland species.

Bock, C. E., V. A. Saab, T. D. Rich, and D. S. Dobkin. 1993. Effects of livestock grazing on Neotropical migratory landbirds in western North America. Pages 296-309 in D. M. Finch and P. W. Stangle, editors. *Status and management of Neotropical migratory birds*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-229. 422 pp.

To enhance value of CRP grasslands to landowners, authors advocated moderate grazing by livestock or controlled haying of CRP. They argued that haying and moderate grazing of CRP, coupled with establishment of livestock exclosures on public lands, would enhance value of public rangelands for wildlife.

Bogenschutz, T. R. 1992. An evaluation of corn and sorghum as a winter food source for ring-necked pheasants. M.S. thesis. University of South Dakota, Brookings. 65 pp.

Corn and sorghum furnished higher quality winter food for pheasants than did natural wild foods and soybeans. Natural foods were high in fiber and low in digestible energy; soybeans contained trypsin, a digestive inhibitor that lowered the metabolizable energy content of the diet. Sorghum provided superior winter cover. Author recommended that food plots include both corn and sorghum. If winter cover is not limiting, corn is a better option. However, if winter cover is limiting, then sorghum food plots are recommended.

Bohning-Gaese, K., M. L. Taper, and J. H. Brown. 1993. Are declines in North American insectivorous songbirds due to causes on the breeding range? *Conservation Biology* 7:76-86.

Authors argued that decline in migratory songbird populations in North America were caused primarily by nest failure rather than winter habitat loss. Evidence was presented that predation had a major impact on population trends; terrestrial mammals were perhaps the most important nest predators. Low and open nests

were especially vulnerable to nest predation. Authors suggested that even a small effect of cowbird parasitism was enough to cause a negative replacement rate and population decline in songbird populations experiencing high predation rates.

Bolen, E. G., L. M. Smith, and H. L. Schramm Jr. 1989. Playa lakes: Prairie wetlands of the southern High Plains. *Bioscience* 39:615-623.

Playa lakes and wetlands significantly increased plant and animal diversity in an intensively cultivated landscape of the southern High Plains. Playas are closed systems with a vertebrate fauna dominated by birds. Lagomorphs also reach high densities in playa habitat. Playas developed for agriculture had greater water level fluctuation and lower insect production than unmodified basins. Playas that received irrigation runoff had increased interspersion of vegetation and open water resulting in higher habitat quality. Cultivation of playas decreased their value as wildlife habitat. Reduction of vegetation surrounding lakes influenced water quality. Establishment of pits reduced the abundance and diversity of emergent vegetation that require periodic drying. Phytoplankton was associated with aquatic macrophytes that were important for production of macroinvertebrates and forage for wintering waterfowl. Pits diminished value of lakes for waterfowl that prefer densely vegetated sites. Losses of littoral and island vegetation reduced waterfowl nesting habitat and reduced production of invertebrates and plant foods important to breeding and wintering waterfowl and shorebirds. Loss of tall emergent and woody vegetation reduced roosting and nesting habitat for other birds. Modified lakes held water during dry seasons and provided habitat during periods of drought. Nonetheless, wildlife benefits remained contingent on the extent of the modification and on the temporal aspects of water-level fluctuations.

Bollinger, E. K., and T. A. Gavin. 1989. Eastern bobolink populations: Ecology and conservation in an agricultural landscape. Pages 497-506 in J. M. Hagan III, and D. W. Johnston, editors. *Ecology and conservation of Neotropical migrant landbirds*. Smithsonian Inst. Press. Washington, D.C. 609 pp.

Authors determined that bobolink abundance was greatest in old hayfields ( $\geq 8$  yr). Authors speculated that abundance increased exponentially with hayfield size because of reduced predation and cowbird parasitism. Densities of eastern meadowlarks, upland sandpipers, Henslow's sparrows, and grasshopper sparrows were all positively correlated with bobolink densities. Authors recommended that conservation practices designed for grassland birds should concentrate on creating or maintaining large habitat patches that resemble old hayfields. They specifically recommended (1) creation or maintenance of patches of relatively sparse grass-dominated cover with some broadleaf forbs and (2) control of woody vegetation.

Boutin, C., K. E. Freemark, and D. A. Kirk. 1999. Farmland birds in southern Ontario: Field use, activity patterns and vulnerability to pesticide use. *Agriculture, Ecosystems and Environment* 72:239-254.

Major determinants of bird distribution in agricultural land were (1) type of crops grown, (2) configuration and physical structure of noncrop habitat, and (3) frequency and extent of agricultural practices such as tillage, pesticide application, and harvest. The lack of data on avian use of cropland in different agricultural landscapes was a major obstacle in assessing the effects of agriculture in many areas of North America. Most species surveyed used edge habitat significantly more than expected. More arthropods were found in field edges than in interiors. Many field margins or herbaceous borders were either sprayed directly for control of pests or were subjected to spray drift. Spraying of edges further reduced biodiversity in agricultural landscapes that already were depauperate.

Bowen, B. E., and A. D. Kruse. 1993. Effects of grazing on nesting by upland sandpipers in south central North Dakota. *Journal of Wildlife Management* 57:291-301.

In central Great Plains, sandpipers nested in grazed fields rather than in ungrazed fields with tall vegetation; however, grazing during the late spring and early summer had a detrimental effect on reproduction. Authors recommended that grazing should be delayed until at least mid- to late June and that traditional season-long grazing from June to October should be avoided. Autumn grazing at high stocking rates may be an acceptable alternative.

Boyd, H. 1985. The large-scale impact of agriculture on ducks in the prairie provinces, 1956-81. *Canadian Wildlife Service Progress Notes* 149. 31 pp.

Brady, S. J. 1988. Potential implications of Sodbuster on wildlife. *Transactions of the North American Wildlife and Natural Resources Conference* 53:239-248.

Analysis of the effects of Sodbuster component of Highly Erodible Land provision of the Food Security Act of 1985 on wildlife. Assuming that most farmers will continue to participate in USDA farm programs, author suggested that provision will discourage conversion of highly erodible land to cropland, thereby benefiting wildlife by minimizing erosion and sedimentation, water quality degradation, and loss of habitat diversity and abundance. Further, greatest benefit will likely be reduced sediment delivery to aquatic ecosystems.

Brennan, L. A. 1991. How can we reverse the northern bobwhite population decline? *Wildlife Society Bulletin* 19:544-555.

Sharp, widespread declines in bobwhite populations since the 1970s were attributed to clean farming practices; forest management systems that maximize basal area; increasing farm size and elimination of weedy fencerows; conversion of marginal farmlands to pine plantations; and direct and indirect effects of pesticides. Indirect effects of pesticides on quail are poorly understood. Agricultural chemicals indirectly affect game population by suppressing arthropod populations that are key food resources for broods. Weeds provide food and feeding substrates that are essential for growth and development of chicks. Author concluded that potential for CRP to enhance habitat was far from being realized. He recommended curtailment of mowing during peak nesting season and periodic disturbance of CRP (e.g., strip-disking) to maintain annuals and forage production.

Brennan, L. A. 1993. Future directions for bobwhite quail and wildlife research in the southeastern United States. *Proceedings of the 1993 Tall Timbers Game Bird Seminar*. Tall Timbers Research Station. Tallahassee, Florida.

Author reported that arthropod abundance increased in response to burning and strip-disking. However, herbicides disrupted the food chain and limited populations. Specifically, widespread application of herbicides suppressed weeds and reduced availability of insect populations needed by bobwhite hens and chicks. He recommended modification of herbicide application to benefit bobwhites in the Southeast.

Brennan, L. A. 1993. Strategic plan for quail management and research in the United States: Introduction and background. Pages 160-169 in *Quail III: National Quail Symposium*. Kansas Department of Wildlife and Parks, Pratt.

Habitat management by the private sector is apparently having little broad-scale impact on bobwhite populations. Interest in quail is large and growing. Author emphasized the need for creative professional leadership to solve problems caused by changing land use patterns. Detrimental effects of federal agricultural policies include annual spring burning, summer mowing, cool-season grasses (e.g., tall fescue and brome), promotion of extensive pine monocultures, and lack of flexibility in management. Paper provided detailed recommendations for modification of federal agricultural policies to improve conditions for quail.

Bryan, G. G., and L. B. Best. 1991. Bird abundance and species richness in grassed waterways in Iowa rowcrop fields. *American Midland Naturalist* 126:90-102.

Study examined bird abundance and species richness in grassed waterways and rowcrop fields in Iowa. Grassed waterways located in cornfields and soybean fields were planted to smooth brome. Authors observed 48 bird species in waterways compared to 14 in croplands. Total bird abundance three-times greater in waterways than in croplands. No species were exclusive to croplands. Authors suggested that unmowed waterways provided important habitat for birds in mid- to late summer because other grass-dominated cover types had earlier been disturbed (e.g., mowing). Current mowing recommendation is to mow after July 15, but 53% of all species observed and all of the breeding species were at peak abundance in the waterways during July 4-22. Authors, therefore, recommended that waterways be mowed in late August or early September. Further, mowing should not be undertaken after mid-September because mowing would reduce the amount of winter cover and residual vegetation required for early spring nesting.

Bryant, F. C., and L. M. Smith. 1987. The role of wildlife as an economic input into a farming or ranching operation. Pages 95-98 in J. E. Mitchell, editor. *Impacts of the Conservation Reserve Program in the Great Plains*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-158.

The economic return of wildlife to Texas landowners varies widely, but in some instances exceeds net revenue generated by livestock and cash crops. Authors argued that CRP provides High Plains and Rolling Plains farmers and ranchers an opportunity to enhance wildlife on their land and increase their income. Management recommendations were provided for improving CRP lands for ring-necked pheasant, lesser prairie chicken, waterfowl, and big game.

Bultsma, P. M. 1995. Ducks and CRP. *Proceedings of the Annual Meeting of the Society of Range Management* 48:9 (abstract only).

Burger, L. D., L. W. Burger Jr., and J. Faaborg. 1994. Effects of prairie fragmentation on predation on artificial nests. *Journal of Wildlife Management* 58:249-254.

Artificial nests placed in smaller prairies had greater depredation rates than those in larger prairies (37 vs 13.9%). Although highest predation rates were observed in smallest prairie size classes and prairie size had an effect on predation, proximity to woody cover was the most important factor affecting predation rates on artificial nests. High predation rates observed in small prairies were attributed to the increased proportion of area near woody cover. Authors concluded that the potential effects of prairie size and woody vegetation on success of ground-nesting birds should

be considered in decisions of acquisition and management of prairie habitats.

Burger, L. W. Jr., E. W. Kurzejeski, T. V. Dailey, and M. R. Ryan. 1989. Structural characteristics in CRP fields in northern Missouri and their suitability as bobwhite habitat. *Transactions of the North American Wildlife and Natural Resources Conference* 55:74-84.

Study of vegetative conditions on CRP lands in northern Missouri from 1986 to 1988 with discussion and recommendations concerning value of CRP lands as winter, nesting, and brood-rearing cover for bobwhite quail. Structural characteristics of vegetation, dominant vegetation types, and frequency of disturbance were examined in relation to year, conservation practice, and season. Authors concluded that (1) emergency haying of CRP contributed to decline in habitat quality, (2) year of establishment or age of field was major factor affecting a field's seasonal habitat value for quail (i.e., value of CRP fields as brood-rearing and roosting cover declined, while nesting cover improved from year 1 to year 3), and (3) vegetative cover and habitat quality varied among conservation practices (CP4 > CP2 > CP1). Authors recommended that mowing be restricted; portions of CRP fields be disturbed on three-year rotation to maintain early successional habitats; and management for diverse age-classes among CRP fields within quail home range.

Burger, L. W. Jr., E. W. Kurzejeski, T. V. Dailey, and M. R. Ryan. 1993. Relative invertebrate abundance and biomass in Conservation Reserve Program plantings in northern Missouri. Pages 102-108 in K. E. Church and T. V. Dailey, editors. *Quail III: National Quail Symposium*. Kansas Department of Wildlife and Parks, Pratt.

Evaluation of relative invertebrate abundance, biomass, and diversity in CRP fields planted to red clover/timothy, timothy, orchardgrass, tall fescue, warm-season grasses, orchardgrass/Korean lespedeza, and conventionally tilled soybeans. Fields planted to red clover/timothy mixture and dominated by red clover had highest levels of invertebrate abundance and biomass. Mean invertebrate abundance and biomass in CRP fields were four-times that of soybean fields. CRP fields could furnish high quality brood habitat for avian species if legumes are incorporated, or maintained, in CRP plantings.

Cable, T. T. 1991. Windbreaks, wildlife, and hunters. Pages 35-55 in J. E. Rodiek and E. G. Bolen, editors. *Wildlife and habitats in managed landscapes*. Island Press, Washington, D.C.

Author stated that even though their value was widely recognized, windbreaks continue to be lost and degraded. For example, annual loss of hedgerows in five midwestern states was estimated to be 0.6-3.1%. The importance of windbreaks varies according to needs of specific wildlife species, both residents and migrants. Less than 3% of the Great Plains is forested. Although woodland habitats are scarce, woodland birds account for 46% of avifauna in western Kansas. Windbreaks may provide reproductive, escape, and protective cover that is particularly important during severe winter weather. Shelterbelts also provide additional sources of food, both seed and insects. Number of species and individuals that were completely or partially insectivorous increased as the size of the windbreak increased. Windbreaks in agricultural landscape serve as travel corridors and dispersal habitat between riparian habitats and other wooded covers. Value of shelterbelts to wildlife typically a function of size, number of rows, plant diversity, and vegetation height. Author indicated that placement was better for wildlife if located in or adjacent to grain fields rather than grazed pasture. He cautioned that shelterbelts may result in higher rates of predation on ground nesting birds in vicinity of wooded cover.

Caithamer, D. F., and G. W. Smith. 1995. North American ducks. Pages 34-37 in E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. *Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems*. U.S. Department of the Interior, National Biological Service. Washington, D.C.

Authors summarized status and trends of breeding and wintering North American ducks between 1955 and 1993. Estimated annual numbers and trends (1984-1993) of ducks were presented based on midwinter and breeding surveys. Sources of variation in waterfowl numbers were discussed. Authors concluded that maintaining or increasing habitat was needed to stabilize or increase waterfowl numbers, and agricultural policies and practices can profoundly affect habitat availability in North America.

Camp, M., and L. B. Best. 1994. Nest density and nesting success of birds in roadsides adjacent to rowcrop fields. *American Midland Naturalist* 131: 347-358.

Evaluation of nest densities and nesting success of birds in roadsides in an intensively farmed area in central Iowa in 1990-1991. Data obtained for 120 nests of eight species in 34 roadside areas. Microhabitat of nests was described for red-winged blackbird, pheasant, gray partridge, and vesper sparrow. Recommended seeding native grasses and forbs, retaining fences, periodic burns to maintain vegetation vigor, and avoidance of mowing, except for shoulders.

Campa, H. III, and S. R. Winterstein. 1992. Wildlife and vegetative response to diverted agricultural land in Gratiot County, Michigan. Michigan State University, Department of Fisheries and Wildlife Annual Report. December 1992. 26 pp.

Study detected significant differences in % canopy cover, height, total canopy, % grass canopy, % litter cover among diverted agricultural fields, but none of these differences were consistently related to field age. Older fields tended to be characterized by a greater percentage cover of grass and litter. Younger fields tended to have greater forb and live canopy cover. Younger fields supported greater avian densities and diversities, but reproductive success was higher in older fields. Authors suggested that differences in reproductive success of birds in young and old fields were associated with vegetative structure and availability of suitable nesting sites.

Capel, S., B. Carmichael, M. Gudlin, and D. Long. 1995. Wildlife habitat needs assessment, Southeast region. Transactions of the North American Wildlife and Natural Resources Conference 60:288-299.

Authors proposed that 1995 Farm Bill should elevate wildlife to coequal status with soil, water, and commodity production control. Additionally, they recommended the following changes in farm program administration and policy: (1) fully activate state technical committees and include state natural resource agency representation; (2) FSA county committee system should be diversified to include state natural resource agency representation, and STC decisions should be binding on county committees; (3) funding should be provided to staff program areas with biologists; and (4) funding should be provided for farm conservation planning. Goals were presented for grassland, shrub-early successional, wetlands, forests, and aquatic habitats. Proposed Farm Bill strategy was outlined.

Carmichael, D. B. Jr. 1997. The Conservation Reserve Program and wildlife habitat in the southeastern United States. Wildlife Society Bulletin 25:773-775.

Author suggested that wildlife benefits associated with CRP were reduced in southeastern states compared to that in the Midwest and Great Plains. He argued that pine plantations and tall fescue provided only limited benefits to wildlife. Pine plantations created under CRP resulted in loss of early successional and agricultural habitats. Fescue forms dense sod that is impenetrable by smaller animals. Author provided recommendations to improve CRP.

Carroll, C. R. 1992. The interface between natural areas and agroecosystems. Pages 365-383 in C. R. Carroll, J. H. Vandermeer, and P. Rosset editors. Agroecology. McGraw-Hill, New York.

Author presented information on the effects of surrounding land uses on natural areas embedded in agricultural landscapes. Farming systems generate weedy phenotypes, including plants, animals, and pathogens that may become invaders of natural areas. Use of crops by some wildlife species may magnify their importance in ecosystems. For example, crows, bluejays, and raccoons, important predators on bird nests, have disproportionately benefited from agricultural expansion.

Natural areas may become fragmented within agricultural landscapes. Fragmentation increases boundary phenomena, resulting in exacerbation of edge impacts. Loss of natural areas generally means that remaining patches are increasingly isolated; consequently, recolonization is difficult, increasing likelihood of local extinctions. Most of these impacts are cumulative and proceed as a consequence of many independent decisions that are made without regard to possible combined effects. Author maintained that little attention has been given to analysis of long-term and broad scale effects of fragmentation.

In absence of active ecological management, most small natural areas begin to degrade and become less representative of the original ecosystem. Small sites typically require more management effort per unit area than is required for large areas. Long-term security of natural areas in agricultural landscape will strongly depend on the way that the land surrounding the natural area is used. Surrounding land uses must be economically sustainable, socially equitable, and explicitly linked with management objectives in the embedded natural area.

Factors that should be addressed in the design of agricultural buffer zones include:

- (1) Design of agricultural areas should be explicitly related to the ecological management goals of the natural area.
- (2) Activities and processes that degrade the habitat, such as invasion by weeds and fire, should be minimized.
- (3) Buffer zone activities should be able to be modified to meet new contingencies. Programs should be flexible so that change can be made without drastically disrupting local economy.
- (4) Buffers should not be sensitive to rapid change in market prices, rising production costs, or decreasing market returns.
- (5) Buffers should not rely on intensive use of agrochemicals, fire, or other methods that may strongly impact nearby natural areas.

Castrale, J. S. 1985. Responses of wildlife to various tillage conditions. *Transactions of the North American Wildlife and Natural Resources Conference* 50:142-156.

Evaluation of minimum tillage practices on wildlife use of agricultural fields, primarily corn and soybeans. Three factors were major contributors to wildlife use of fields: food availability, vegetation structure, and disturbance. Under most circumstances, availability of insects probably did not limit wildlife populations in agricultural fields. Preferred foods may be readily available in corn and soybean fields, but lack of adequate cover or vegetation characteristics may prevent some species from utilizing resources present.

Center for Resource Economics. 1992. Farm Bill 1990 revisited. Center for Resource Economics, Washington, D.C. 44 pp.

Cihacek, L. J. 1993. Selection criteria for retention of CRP land in permanent cover. Pages 41-88 in *Proceedings of the Great Plains Agricultural Council. Annual meeting, June 2-4, 1993, Rapid City, South Dakota.*

Clark, R. G., and T. D. Nudds. 1991. Habitat patch size and duck nesting success: The crucial experiments have not been performed. *Wildlife Society Bulletin* 19: 534-543.

Authors argued that there was conflicting evidence concerning relationship between patch size and nest success of upland nesting birds. Whereas some studies showed that nest success increased with greater area and lower density of nests, others indicated that there was no positive relationship between area and success. They argue that more information about relationship between patch size and composition of managed habitats and duck nesting success is needed. Key questions include: (1) What kind of cover needs to be planted and how much? (2) Are ducks doing better in managed patches than in unmanaged patches? (3) What is the standard of comparison (e.g, nest success, duckling survival)? (4) Are program costs effective? Their review of literature did not clearly support or refute the hypothesis that duck nesting success should be greater in larger patches. Authors criticized the rationale of establishing relatively small (< 300 ha) areas of cover and suggested that effort and limited funds be redirected to changing agricultural policy and programs.

Clark, W. R., and T. R. Bogenschutz. 2000. Grassland habitat and reproductive success of ring-necked pheasants in northern Iowa. *Journal of Field Ornithology* 70:380-392.

Incubation initiation date, clutch size, and nest and hen success of pheasants compared between Iowa study sites having high habitat diversity with 25% grassland and low habitat diversity with 9.3%

grassland. There were no differences between study sites in initiation dates of first nests or clutch size; initiation date of second nests was earlier and hen and nest success were greater in high diversity than in low diversity area. Nest success was negatively related to patch size.

Clark, W. R., R. A. Schmitz, and T. R. Bogenschutz. 1999. Site selection and nest success of ring-necked pheasants as a function of location in Iowa landscapes. *Journal of Wildlife Management* 63:976-989.

Study of site selection and nest success of ring-necked pheasants as a function of location in Iowa landscapes. Success was highest in fields  $\geq 160$  acres. Cover in several large blocks was better than one large block. Both probability of nest-site selection and nesting success were influenced by configuration of habitat within one home range radius of nest site. Specific vegetation type at nest location was not predictive of selection or success. Authors suggested that biologists must understand how landscape configuration is influenced by agricultural policy if managers are ultimately to influence wildlife populations. They recommended that managers strive to provide undisturbed grassland in blocks of  $\geq 15$  ha (40 acres) for nesting pheasants.

Cline, G. A. 1988. Habitat relationships of bobwhite quail and cottontail rabbits on agricultural lands in Halifax County, Virginia. M.S. thesis. Virginia Polytechnic Institute and State University, Blacksburg. 99 pp.

Author evaluated Habitat Suitability Index (HSI) models for bobwhite quail and cottontail rabbits on agricultural lands in Halifax County, Virginia. Wooded fallow fields, length of pasture/fallow, forest/forest edge, and total number of all edges present were positively related to quail presence. Author recommended that the number of different edges and number of fallow fields in early successional stages be maximized. Cultivation of field borders, corners, waterways, and other idle areas should be discouraged. He suggested that a large number of small fields, each with a fallow or brushy border, was better than same acreage encompassed in only a few fields. Author concluded that models correctly predicted habitat preferences of bobwhites.

Cochrane, W. W. 1993. The development of American agriculture: A historical analysis. University of Minnesota Press, Minneapolis. 500 pp.

A thorough and arresting review of agricultural development in the United States from the early colonial period to 1990. Author described changes in agriculture in relation to settlement, industrialization, technological development, and expansion to world markets. The book furnished a historical perspective on current agricultural policies and their implications for environmental policy and continuing development of the agricultural sector.

Conover, M. 1998. Perceptions of American agricultural producers about wildlife on their farms and ranches. *Wildlife Society Bulletin* 26:597-604.

Survey of attitudes of American agricultural producers about wildlife on their farms and ranches. Agricultural producers control 45% of U.S. surface area representing enormous potential impact on wildlife resources. Survey indicated that agricultural producers generally placed high value on wildlife and annually spent millions of dollars trying to enhance wildlife populations on farms and ranches. Improvement activities included providing cover or water and leaving a portion of crop or residue for wildlife use. Conversely, crop damage by wildlife can be expensive and severe and may limit participation by agricultural producers in wildlife enhancement efforts.

Cook, K. A. 1994. So long, CRP. Environmental Working Group/The Tides Foundation Report. Washington, D.C. 38 pp.

Cook, K. A., and A. B. Art. 1993. Countdown to compliance: implementation of the resource conservation requirements of federal farm law. Center for Resource Economics. Washington, D.C. 37 pp.

Council for Agricultural Science and Technology. 1990. Ecological impacts of federal Conservation and Cropland Reduction Programs. Task Force Report No. 117. Ames, Iowa. 28 pp.

Overproduction in agriculture first became a major problem following WWI. High demand for food and fiber during the war quickly disappeared after the war. This pattern was repeated following WWII. World demand was a major factor influencing domestic production and prices. Technological advancements and increased productivity per acre also contributed to overproduction. Between 1930 and 1980, farm production rose by almost 150%. If CRP reaches its goal of 45 million acres, it is estimated that soil erosion will be reduced by 850 million tons/yr. Other CRP benefits include improved ground surface water quality, reduced nitrate and pesticide use, and decrease in commodity surpluses. Task force recommendations included: (1) extend period that a field may be idled from one to three to five years; (2) ban fallowing of idle land without cover; (3) require ASCS to consider wildlife when setting rules for seeding and destruction of cover; and (4) include natural resource professionals on ASCS committees.

Council for Agricultural Science and Technology. 1995. The Conservation Reserve: A survey of research and interest groups. Special Publication 19. Ames, Iowa. 44 pp.

Cowardin, L. M., D. S. Gilmer, and C. W. Shaiffer. 1985. Mallards and agricultural programs. *Transactions of the North American Wildlife and Natural Resources Conference* 49:132-140.

Declining quality of wildlife habitat has not been considered a high priority problem by ASCS committees charged with allocating Agricultural Conservation Program dollars. Prior to the 1985 Farm Bill, biologists from 12 of 14 midwestern states documented declines in wildlife populations related to changing land uses and agricultural practices. Specifically, analysis revealed a 91% decrease in pheasants, 72% decline in cottontails, and 83% decline in bobwhites. Population declines were attributed to conversion of quality nesting cover, small grains, pasture, and other nonfarmed cover types to rowcrops. Factors also identified as contributing to reduced habitat quality were loss of edge, old farmsteads, wetlands and idle areas; increased farm and field size; and a major shift from diversified farms to simplistic agricultural landscapes. Authors summarized weak points of agricultural programs (e.g., Payment in Kind) and offered basic wildlife recommendations for 1985 Farm Bill.

Cowardin, L. M., A. B. Sargent, and H. F. Duebbert. 1983. Low waterfowl recruitment in the prairies: The problem, the reasons, and the challenge to management (abstract only). Pages 16-18 in H. Boyd, editor. *First Western Hemisphere Waterfowl and Waterbird Symposium*. International Waterfowl Research Bureau, Slimbridge, England.

Estimates of waterfowl nest success in the northern United States were in the range of 5-15%, except in western North Dakota where success rates of 38% and 42% were reported. Authors indicated that differences in success reflected variation in habitat quality and predator populations. Lowest success rates were observed in areas with intensive agriculture. Authors tied low waterfowl recruitment to destruction of habitat and increased predation rates in remaining suitable habitat. They argued that intensive agriculture had decreased both the availability of nesting cover and habitat available to resident prey species. As a result, nesting ducks and foraging predators were concentrated in remaining untilled grassland. They proposed that a key management strategy should be to separate nest predators from nesting waterfowl. The authors concluded that habitat preservation is essential but also requires purposeful management of predators.

Cowardin, L. M., T. L. Shaffer, and K. M. Kraft. 1995. How much habitat management is needed to meet mallard production objectives? *Wildlife Society Bulletin* 23:48-55.

Application of cost-benefit analysis of management required to increase mallard recruitment in Prairie Pothole Region. Simulations provided guidance for managers seeking to optimize allocation of limited resources for mallard recruitment.

Cully, J. E., and H. L. Michaels. 2000. Henslow's sparrow habitat associations on Kansas tallgrass prairie. *Wilson Bulletin* 112:115-123.

Examination of macro- and microhabitat characteristics of Henslow's sparrows breeding on Kansas military reservation, 1995-1996. Sparrows associated with grassland two to three years after burning. Compared to random survey points, use sites had lower tree density, but similar shrub density and military disturbance. Use sites characterized by tall, dense, structurally homogeneous vegetation with high litter cover.

Curtis, J., T. Profeta, and L. Mott. 1993. After silent spring: the unsolved problems of pesticide use in the United States. Natural Resources Defense Council. New York. 56 pp.

In 1991, 2.2 billion pounds of pesticides, or 8 pounds for every man, woman, and child in the country, were applied in the United States. Seventy-one active ingredients in pesticides that have been found to cause cancer in animals or humans were used on food crops. EPA estimated that 10% of public wells and 440,000 rural private water wells contained pesticides. At a minimum, 1.3 million people were drinking water contaminated with one or more pesticides.

Agriculture generally is considered the largest source of surface water pollution in the United States and pesticides are one of the principal contaminants. A recent USGS study of the Mississippi River Basin detected carcinogenic herbicide atrazine in 100% of samples; levels exceeded the federal drinking water standard in 27% of samples. Atrazine levels were three-times the legal limit in Platte River samples. Herbicides were used on 95% of corn and soybean farms. In 1991, the amount of active ingredients applied to farmland was 2.7 lb/acre. There are 25,000 chemical products on the market today containing approximately 750 active ingredients.

Groundwater is the primary source of drinking water for 97% of rural residents and > 50% of total U.S. population. EPA (1988) documented 74 different pesticides in groundwater samples from 32 states. Since 1962, number of pesticide-resistant insects and mites has risen from 137 to 447. Additionally, over 100 species of plant pathogens and 48 species of weeds have developed pesticide resistance. Pesticide use can be reduced from 25 to 80% on nine major U.S. crops by using practices such as integrated pest management, biological control, crop rotations, cover crops, and ridge-tillage.

In 1990, 38% of U.S. food samples contained pesticides. This estimate was considered conservative because the five most commonly used laboratory tests were able to detect only half of pesticides used on foods. At least 300 different pesticides are used on food, 71 of which are known carcinogens. Other pesticides are neurotoxic and reproductively toxic, causing premature birth and low birth weight. Conventional laboratory methods can only detect 203 of 426 pesticides FDA has identified as likely to leave residues in food. Children are getting larger doses of pesticides because their food intake is larger percentage of body weight. For example, the average toddler drinks 31-times more apple juice as percentage of body weight than the mother.

Recent (1992) NOAA report documented fish kills, and decreased mean density and diversity of species due to runoff of 35 commonly used agricultural pesticides into coastal waters.

Cutler, M. R. 1991. Meeting the biodiversity challenge through coordinated land use planning. *Renewable Resources Journal* 9:13-16.

Dahlberg, K. A. 1992. The conservation of biological diversity and U.S. agriculture: Goals, institutions, and policies. *Agriculture, Ecosystems and Environment* 42:177-193.

Agriculture's transformation over the past several decades has led to an increasing genetic depletion in farm habitats and rural landscapes. Ways to modify policy to enhance diversity in agricultural landscapes include making changes in current set-aside policies, credit programs, and rangeland management. Water and energy should receive priority, but aesthetic value and diversity of rural landscapes should also be considered. Author suggested that the goal should be to achieve a more diversified lower-input agricultural system.

American agriculture has gone from small scale, diversified production, local marketing systems dependent largely upon human and animal labor to large-scale monocultures dependent on cheap energy and large markets. Size of rural populations and the number of farmers in U.S. population have declined. Pressures to expand production have led to greater simplification of the agricultural ecosystem and elimination of habitat for wildlife and pest predators, and increased soil erosion and groundwater pollution.

An important part of seeking new policy direction will be to educate the public regarding the value and importance of rebuilding a strong, diverse rural America. Author recommended changes in current set-aside policies designed to reduce overproduction. Farmers in grain-growing areas should be encouraged to leave unharvested portions of fields as cover.

Danielson, B. J. 1992. Habitat selection, interspecific interactions and landscape composition. *Evolutionary Ecology* 6:399-411.

Author described three types of habitats: (1) sources—reproduction exceeds mortality; (2) sinks—reproduction limited, inadequate to compensate for mortality; (3) unusable habitats—comprises the matrix of all habitats that are never exploited by the species. Patches of source and sink habitat are embedded in usable habitat. Preserving population and community characteristics that have evolved under natural conditions by restoring landscapes to natural state is rarely possible. May be able to compensate for fragmentation where unusable habitats have been increased by clustering patches of usable habitat and connecting the patches with dispersal corridors. Author emphasized that spatial scale of conservation efforts must be defined by the ecology of the species in question.

Davis, C. A., T. Z. Riley, R. A. Smith, H. R. Suminski, and M. D. Wisdom. 1979. Habitat evaluation of lesser prairie chickens in eastern Chaves County, New Mexico. Department of Fisheries and Wildlife Sciences, New Mexico Agricultural Experiment Station. 141 pp.

Recommended 64 ha exclosures to ensure sufficient winter cover and nesting habitat for lesser prairie chickens in eastern Chaves County, New Mexico.

Davis, M. A., D. W. Peterson, P. B. Reich, M. Crozier, T. Query, E. Mitchell, J. Huntington, and P. Bazakas. 2000. Restoring savanna using fire: Impact on breeding bird community. *Restoration Ecology* 8:30-40.

Analysis of the effects of fire on oak savanna avian community. Insectivorous birds that feed in upper canopy declined, while omnivorous ground feeders and insectivorous bark gleaners increased during restoration. Overall, savanna restoration resulted in increases in abundance of open country birds, including many declining bird species of special conservation concern.

Davidson, J. H. 1995. Conservation agriculture: An old new idea. *Natural Resources and Environment* 9:20-22.

Response to agricultural impacts to environmental quality by lawmakers has been cautious and exploratory. They have shown a clear reluctance to impose regulatory constraints on producers. Environmental Conservation Acreage Reserve Program (ECARP) consisting of CRP and WRP was created to assist owners and operators of highly erodible land, fragile lands, and wetlands in improving soil and water quality. Continued high levels of erosion and water contamination strongly suggest that conservation measures are not being universally applied or continued. The author indicated that the primary reason for continued erosion is USDA shift from soil-conserving practices to production enhancement. The amount of voluntary compliance by private landowners roughly parallels the amount of federal cost-sharing dollars

available. Federal programs that rely on voluntary adoption of conservation practices have not worked well in the past. The author concluded that environmental quality goals would only be reached with subsidies or regulation.

Delisle, J. M., and J. A. Savidge. 1997. Avian use and vegetation characteristics of Conservation Reserve Program fields. *Journal of Wildlife Management* 61: 318-325.

Comparison of avian use of CP1 (cool-season grasses and legumes) and CP2 (warm-season, native grasses in southeastern Nebraska). Total bird abundance did not differ between CP1 and CP2. In winter and breeding season, CP2 had taller denser vegetation than CP1 fields. Bobolinks and meadowlarks were more abundant in CP1. Sedge wrens preferred fields with structurally complex vegetation but disappeared after these fields had been mowed or burned. Common yellowthroats were associated with tall vegetation and were more abundant in CP2. Grasshopper sparrows disappeared from fields as litter depth increased and dead vegetation accumulated. CP2 fields that were mowed three out of four years maintained consistent grasshopper sparrow numbers. CP2 was preferred by pheasants for winter cover. Authors concluded that native plantings alone could provide habitat for all native birds if some fields were managed more intensively to simulate historical disturbances. CP1 provided the best habitat for species that nested directly on ground and preferred low vegetation height and litter depth. CP2 was used by species that nested higher in vegetation and preferred dense growth.

Dicks, M. R. 1994. Costs and benefits of CRP. Pages 39-44 in *When Conservation Reserve Program contracts expire: The policy options*. Soil and Water Conservation Society, Ankeny, Iowa.

This article reported that the CRP has provided numerous benefits. However, the author was unable to estimate net gains or losses to society due to CRP at the end of the first 10-year contract period. He stated that is imperative to determine the social response to landowners' post-CRP intentions. The author concluded that this type of information is vital to determine if the \$19 billion spent at the time of this study was cost effective and if any future expenditures have measurable benefits to society.

Dicks, M. R., and J. E. Coombs. 1995. CRP in the future. Great Plains Agricultural Policy Center. Oklahoma Agricultural Experiment Station, Oklahoma State University, Stillwater.

Dicks, M. R., L. D. Sanders, and S. Anderson. 1990. Agricultural ecopolitics: Conflicts of agricultural policies with resource conservation and sustainable agriculture. Pages 89-98 in P. J. Hoefer, G. H. Fechner, and S. E. McDonald, technical coordinators. *Trees are the answer*: Great Plains Agricultural Council, Forestry Committee, Publication No. 132.

Central theme of federal agricultural policy is controlling the variability in agricultural production and commodity prices. During first 150 years of American history, federal policy successfully promoted the expansion of U.S. farmland. Past agricultural policy may have influenced resource use. Current policy is shifting focus to supply management, placing restrictions on resource use rather than just land use. The greatest need for education and research rests with integrating conservation practices with cropping systems.

The 1980s were a transitional decade for agricultural policy with focus shifting from production control to production management. The environmental impacts of alternative agricultural production control policies were considered during the development and implementation of legislation. Since the 1930s, agricultural policies have sought to modify farmers' allocation of resources almost exclusively through use of positive and negative incentives.

Peak of U.S. farmland acreage was over 1.2 billion acres in the 1950s. Farmland acreage devoted to cropland peaked at nearly 395 million acres in early 1950s. Total production of the basic commodities has grown rapidly since the 1950s as technology brought improvements in productivity. Federal policies designed to boost agricultural output through research and extension continue to achieve this goal.

Diebel, P. L., T. T. Cable, and P. S. Cook. 1993. The future of Conservation Reserve Program land in Kansas: The landowner's view. Kansas Agricultural Experiment Station, Kansas State University, No. 94-45-S. 56 pp.

The majority of survey respondents were satisfied with CRP and ranked soil erosion as an important influence in initial enrollment. Wildlife habitat considerations affected decisions of 67.7% of respondents. However, 57.6% said increases in wildlife populations were undesirable. Hunting was most frequent form of recreation allowed on CRP land (76.4%). Market prices, forage, and livestock were key factors in decision about future use of CRP land.

Dillaha, T. A. III, J. H. Sherrard, and D. Lee. 1989. Long-term effectiveness of vegetative filter strips. *Water, Environment and Technology* 1:418-421.

Summary of filter strip effectiveness. Taller weeds shaded desirable grasses and reduced effectiveness. Mowing, herbicides, and reseeding or combinations of the three could improve effectiveness. Cattle decreased quality and effectiveness of filter strips.

Dijak, W. D., and F. R. Thompson III. 2000. Landscape and edge effects on the distribution of mammalian predators in Missouri. *Journal of Wildlife Management* 64:209-216.

Relative abundance of forest songbird nest predators (raccoons, opossums, and striped skunks) was examined at local and landscape scales to determine predation risks in Missouri. Raccoon abundance was related to latitude, stream density, and mean patch size of agricultural lands. Opossum abundance was related to stream density, contagion, mean nearest neighbor distance between forest patches, and latitude. Skunk abundance was not related to landscape characteristics examined. Raccoons were more abundant along edges than in forest interior. No pattern was observed for opossums. Author concluded that local and landscape patterns affected predator abundance and songbird nest predation rates.

Doak, D. F., P. C. Marino, and P. M. Kareiva. 1992. Spatial scale mediates the influence of habitat fragmentation on dispersal success: Implications for conservation. *Theoretical Population Biology* 41:315-336.

Heterogeneity has different and conflicting effects on animal movement at different scales. Explicit consideration of scale is essential in discussion of habitat fragmentation and optimal conservation strategy. Major impact of fragmentation is disruption of animal dispersal at two scales: the relative size of the habitat fragments and the spatial scale at which these fragments are arranged. When fragmentation is unavoidable, dispersal mortality may be minimized by clustering habitat fragments. Clustering seems to have a positive influence on dispersal success, but authors cautioned that the appropriate spatial scale of clustering must be defined. Scale affects risks of mortality, degrees of connectivity, or independence among patches and the influence of environmental catastrophes.

Doering, O. 1992. Federal policies and incentives or disincentives to ecologically sustainable agricultural systems. Pages 21-36 in R. K. Olson, editor. *Integrating sustainable agricultural, ecology and environmental policy*. Haworth Press, New York.

Sustainable agriculture involves less use of off-farm inputs while introducing new management and cropping systems that better utilize on-farm resources. Until recently, federal farm policies have not been concerned with environmental issues but rather reflected goals of increased farm income and low cost food for the nation. Other goals, such as improving rural conditions, increasing rural income, improving farming operations, and conserving natural resources, have formed foundation of agricultural policy in recent decades. At times, these policies have conflicted in their goals and outcomes. Future policies must be more highly focused on addressing environmental impact of agriculture if continued support of nonagricultural sector is to be expected. Paper provided useful statistics on changes in quantities of off-farm inputs required

for production in recent decades. Since World War II, use of fertilizers and pesticides has increased because they have become cheap compared to labor, fuel, and machinery. The CRP has reduced environmental problems, but the program does not address environmental concerns relative to those acres remaining in production and the long-term use of CRP acres. There needs to be a stronger emphasis in agricultural policy that considers long-term environmental quality.

Duebbert, H. F. 1969. High density and hatching success of ducks on South Dakota CAP lands. *Transactions of the North American Wildlife and Natural Resources Conference* 34:218-228.

Duebbert, H. F., and J. T. Lokemoen. 1976. Duck nesting in fields of undisturbed grass-legume cover. *Journal of Wildlife Management* 40:729-740.

Study estimated nest density, hatching rates, egg hatchability, and annual duckling production for mallards, blue-winged teals, and gadwalls nesting in Cropland Adjustment Program fields in north-central South Dakota, 1971-1973. Nesting cover consisted of introduced cool-season grasses and legumes, primarily smooth brome grass, intermediate wheatgrass, and alfalfa.

Dumont, P. G. 1991. Grasslands, wetlands and more wildlife. *Soil and Water Conservation News* 12:6-10.

This article described the CRP sites and landowner attitudes in North and South Dakota. The developing partnership between the U.S. Fish and Wildlife Service and Soil Conservation Service was discussed. The Water Bank Program was briefly mentioned. Photographs illustrated the dramatic responses of wildlife to CRP grasslands and restored wetlands.

Dunn, C. P., F. Stearns, G. R. Guntenspergen, and D. M. Sharpe. 1993. Ecological benefits of the Conservation Reserve Program. *Conservation Biology* 7:132-139.

Unintentional, yet significant, ecological benefits of CRP: reversal of landscape fragmentation, maintenance of regional biodiversity, development of wildlife habitat, and regional changes in carbon flux. Dollar benefits derived from program are difficult to precisely quantify. Nonetheless, authors suggested that overall program costs would be more than offset by benefits from increased net farm income, soil productivity improvements, enhanced water quality, and revenue from recreational activities. These and other benefits should be used by policy makers to justify continuation of the program.

Edwards, W. R. 1984. Early ACP and pheasant boom and bust! - a historical perspective with rationale. Pages 71-83 in R. T. Dumke, R. B. Stiel, and R. B. Kahl, editors. *Proceedings: Perdix III. Gray partridge and ring-necked pheasant workshop*. Wisconsin Department of Natural Resources, Madison.

Ekstrand, E. 1993. Wildlife economics of the CRP. Pages 52-54 in C. Lee, editor. *Will there be a lasting conservation legacy? Proceedings of Midcontinent CRP Conference*, Kansas Wildlife and Parks, Manhattan.

Ekstrand, E., and R. L. Johnson. 1994. Application of farm programs to water quality. Pages 541-544 in D. G. Fontane and H. N. Tuvel, editors. *Water policy and management: Solving the problems. Proceedings of the 21st Annual Conference of the Water Resources Planning and Management Division*. American Society of Civil Engineers, New York.

Ervin, D. E. 1986. Constraints to practicing soil conservation: Land tenure relationships. Pages 95-107 in S. B. Lovejoy and T. L. Napier. *Conserving soil: Insights from socioeconomic research*. Soil and Water Conservation Society, Ankeny, Iowa.

Farmland tenancy in the United States underwent several major changes in the 1970s: percentage of total farmland owned by nonoperator landlords rose, use of fixed-cash rental contracts increased, and landlords contributed a lesser share of total farm production and capital expenditure. These events imply increased separation of ownership from management of farmland. Tenants will only be willing to invest in soil erosion control if the productivity benefits or input cost savings outweigh costs of erosion control during rental period. Landlords may under-invest in soil erosion control because benefits will be captured by tenants who do not share in the costs. Unless tenant operators expect to rent land for an extended period of time or intend to purchase the land, a program oriented to renter will miss the long-term incentives that owners have. Attempts to persuade landowners and tenants that conservation is a good thing without sound data may succeed in short run but approach will ultimately fail when the real benefits and costs are realized. In the mid-1980s, 40% of U.S. farmland was leased.

Ervin, D. E. 1991. Conservation and environmental issues in agriculture. U.S. Economic Research Service, Resources and Technology Division. Washington, D.C. 62 pp.

Evard, J. O., D. A. Snobl, P. B. Doeneir, and J. A. Dechant. 1991. Nesting of short-eared owls and voles in St. Croix County. *The Passenger Pigeon* 53:223-226.

Increased numbers of predators, such as short-eared owls, red foxes, coyote, and rough-legged hawks, were attributed to high concentration of meadow voles in CRP lands. Two short-eared owl nests were found in CRP. This species has rarely been recorded nesting in Wisconsin. Presence of nests attributed to CRP habitat supporting high density of meadow voles.

Faeth, P., R. Repetto, K. Kroll, Q. Dai, and G. Helmers. 1991. Paying the Farm Bill: U.S. agricultural policy and the transition to sustainable agriculture. World Resources Institute. Washington, D.C. 70 pp.

Farmer, A. H., R. L. Hays, and R. P. Webb. 1988. Effects of the Conservation Reserve Program on wildlife habitat: A cooperative study. *Transactions of the North American Wildlife and Natural Resources Conference* 53:232-238.

Description of plant and animal monitoring efforts of CRP lands in the Midwest and northern Great Plains initiated in 1987.

Farris, A. L., and S. H. Cole. 1981. Strategies and goals for wildlife habitat restoration on agricultural lands. *Transactions of the North American Wildlife and Natural Resources Conference* 46:130-136.

Indicators of decline in farmland wildlife habitat are increased urbanization of agricultural land; increased size of farms, field size, and acres in rowcrops; decreased area in production of small grains, wild/tame hay, and pasture; and loss of edge, fencerows, farmsteads, wetland and idle lands. All have contributed to reductions in numbers and diversity of wildlife. Agricultural policy is the primary influence on agricultural land use and farmland wildlife habitat.

Native grasses, while taking more care and time to establish, provide excellent erosion control with significantly lower cost and energy utilization. Long-term benefits of native grasses versus nonnative cool-season grasses are significant. Cutting for hay should be delayed until after July 15. Authors endorsed cost-sharing for farmers that devote a minimum percentage of cropped acreage to permanent cover capable of supporting wildlife. They suggested that 4-5% of landscape probably was sufficient.

Farris, A. L., and R. M. Gray. 1989. Effects of the Conservation Reserve Program on wildlife habitat: Results of 1988 monitoring. *Transactions of the North American Wildlife and Natural Resources Conference* 54:365-376.

Report on vegetative characteristics and pheasant, meadowlark, and eastern cottontail Habitat Suitability Index (HSI) values for CRP lands in Midwest in 1987-1988. Conclusions: (1) Composition of early successional fields dominated by weedy species with persistence of vegetation varying among conservation practices (greatest in CP2); (2) HSI values calculated for early successional fields suggested fair-good nesting habitat for pheasants and meadowlarks, but no improvement for cottontails; (3) introduction of woody plants and persistent herbaceous vegetation and food plots recommended to overcome limitations in winter food and shelter for pheasants; and (4) mowing and haying of CRP fields adversely impacted nesting birds.

Fauth, P. T. 2000. Reproductive success of wood thrushes in forest fragments in northern Indiana. *Auk* 117:194-204.

Analysis of brown cowbird brood parasitism, nest density, nest predation, and reproductive success of wood thrush nests in forest fragments in northern Indiana. Thrush density was negatively related to fragment size. Parasitism of thrush nests was 90%. Number of parasitic eggs/nest was unrelated to fragment size, host abundance, or distance to edge, but positively related to thrush abundance. Nest predation was unrelated to fragment size or distance to edge. Author concluded that thrushes had low fecundity in agriculturally dominated northern Indiana and recommended that conservation efforts be directed at preserving and enhancing habitats in regions where parasitism and predation are reduced.

Fawcett, R. S. 1982. Weed control strategies under different tillage regimes. Page 12 in R. B. Dahlgren, compiler. *Midwest agricultural interfaces with fish and wildlife resources workshop*. Iowa State University, Iowa Fish and Wildlife Cooperative Research Unit, Ames.

Use of selective herbicides resulted in improved weed control, reduced tillage, and increased crop yields. Herbicides apparently have little direct effect on wildlife, but use associated with losses of habitat and forage. About 97% of all corn and soybeans in Iowa were treated with herbicides.

Feather, P., D. Hellerstien, and L. Hansen. 1999. Economic valuation of environmental benefits and the targeting of conservation programs: The case of the CRP. U.S. Department of Agriculture, Economic Research Service. Agricultural Economic Report Number 778. 56 pp.

Report demonstrated how nonmarket valuation models could be used to refine enrollment into conservation programs such as CRP. Environmental targeting was defined as directing resources to lands where the greatest environmental benefit was generated for a given expenditure (i.e., least cost). Report examined use of nonmarket valuation models for freshwater-based recreation, wildlife viewing, and pheasant hunting, and potential changes in distribution of land enrolled in CRP. If public preferences are explicitly known, then such valuation based targeting of CRP might improve performance and benefits of program. Analysis showed that substantial shifts in geographic location of lands enrolled in program may occur depending on what criteria and priorities are used for targeting.

Frawley, B. J. 1989. The dynamics of nongame bird breeding ecology in Iowa alfalfa fields. M.S. thesis. Iowa State University, Ames. 94 pp.

Eight nongame bird species (dickcissel, red-winged blackbird, western meadowlark, common yellowthroat, sedge wren, grasshopper sparrow, and vesper sparrow) established territories in alfalfa fields before mowing. Mowing reduced their numbers and density. Only dickcissels, grasshopper sparrows, western meadowlarks, and vesper sparrows attempted to nest in second growth alfalfa fields. Common yellowthroats selected the tallest, densest vegetation with relatively high coverage of grass; grasshopper sparrows used areas of sparse vegetation. Western meadowlark abundance seemed unrelated to vegetation changes.

Needs of ground nesting birds are difficult to integrate with forage management practices. In Iowa, highest yields and forage quality are obtained by harvesting alfalfa in early June. Fields typically are harvested two more times at five- to six-week intervals. Forage production on private lands will continue to intensify with greater production, new cultivars, and earlier mowing. For example, new species of cultivars will permit earlier mowing while maintaining high yields. CRP may provide some compensation for losses of habitat in alfalfa, but mowing of CRP during the nesting season would negate its potential benefit.

Freemark, K. 1988. Agricultural disturbance, wildlife and landscape management. Pages 77-84 in M. R. Moss editor. *Landscape ecology and management*. Canadian Society for Landscape Ecology and Management Symposium, University of Guelph, Ontario, Canada.

Investigation of bird species richness and reproduction in forested habitats impacted by agricultural production. Wildlife in agricultural landscapes are subject to a number of disturbances, such as habitat fragmentation and pesticide use, which have impact on

their spatial and temporal distribution. Understanding relationships between landscape structure, disturbance and distribution of wildlife is needed to develop better management strategies to minimize potential impact and to enhance the persistence of wildlife community.

Freemark, K. 1995. Assessing effects of agriculture on terrestrial wildlife: Developing a hierarchical approach for the U.S. EPA. *Landscape and Urban Planning* 31: 99-115.

Given the intensive and extensive extent of agriculture, there is a need to develop the conceptual and scientific basis for landscape design and management to promote sustainable agricultural practices that enhance conservation and environmental priorities associated with agricultural ecosystems. Retrospective analysis may provide insights into the range of possibilities for future landscape design and management scenarios in a given area. Major limitation of many previous studies of wildlife on farmland has been the focus on detailed studies of small plots with little regard to larger spatial scales.

Freemark, K., and C. Boutin. 1995. Impacts of agricultural herbicide use on terrestrial wildlife in temperate landscapes: A review with special reference to North America. *Agricultural Ecosystems and Environment* 52:67-91.

Review of the effects of agricultural herbicides on terrestrial wildlife in North America and Europe. Strong evidence cited for adverse effects of chemicals on habitats in temperate landscapes of North America, beneficial insects and arthropods in Europe, and birds in North America and Europe. Authors recommended additional research to develop toxicity testing guidelines for nontarget plants, identify ecologically relevant plant species for laboratory tests, multi-species field tests, improved methods of risk assessment, and mitigation options.

Freemark, K. E., J. R. Probst, J. B. Dunning, and S. J. Heji. 1993. Adding a landscape ecology perspective to conservation and management planning. Pages 346-352 in D. M. Finch and P. W. Stangle, editors. *Status and management of Neotropical migratory birds*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-229. 422 pp.

Populations within individual habitat patches can decline, become extinct, and become reestablished by dispersal of individuals from other patches. The set of local populations that interact through dispersal is a metapopulation. Within a landscape, the probability of local extinction within a habitat patch is inversely related to size of the patch population which is proportional to the size and

habitat quality within the patch. Probability of recolonization is proportional to proximity and connectedness to similar habitat patches and permeability of the intervening matrix. Effective conservation of Neotropical migrant landbirds may require preservation of suitable but intermittently unoccupied habitat. Management plans should protect the diversity of habitats and landscapes used, not just where the species is most common.

Fry, G. L. A. 1991. Conservation in agricultural ecosystems. Pages 415-443 in I. F. Spellerberg, F. B. Goldsmith, and M. G. Morris, editors. *The scientific management of temperate communities for conservation*. Blackwell Scientific Publications, Oxford. Great Britain.

Protected areas alone cannot achieve conservation goals such as maintenance of biological diversity. Incorporation of conservation measures in farm management will demand clear recommendations based on sound theory and evidence gained through practical trials. Maintenance or enhancement of habitat quality for a wider range of plants and animals will require better understanding of ecological processes at the site, field, and landscape levels. The design and management of habitats are constrained by the lack of understanding of the processes involved in animal distribution, the way in which species use corridors, and what constitutes barriers. Connectivity in a landscape that links isolated subpopulations to form metapopulations is one buffer against local extinction processes caused by habitat fragmentation.

Failure to consider effects of the next field or surrounding landscape is an important shortcoming of many investigations of wildlife in agricultural settings. The abundance of many species comprising animal communities on farmlands are controlled largely by a few environmental factors. Both the timing and severity of agricultural practices are important factors governing the potential of agricultural lands for wildlife. Extending the width of field margins farther into the field is one way of increasing habitat diversity on farmlands. Author concluded that management decisions often will need to be made without thorough assessment of the impacts on wildlife.

Furrow, L. T., K. F. Millenbah, R. B. Minnis, A. J. Pearks, H. Campa III, and S. R. Winterstein. 1993. Conservation Reserve Program: Not just for the birds (abstract only). *Proceedings of the Midwest Fish and Wildlife Conference* 55:170.

Gall, G. A. E., and G. H. Orians. 1992. Agriculture and biological conservation. *Agriculture, Ecosystems and Environment* 42:1-8.

Agriculture is the dominant form of land management on all continents. Intensity of management and capital investment in agriculture dramatically increased following World War II. Before that time, agriculture was sufficiently inefficient that habitats were provided for many species of wildlife. Multiple uses of land decline

as intensity of land management increases. When prices of agricultural commodities increase, there is a decrease in consideration for recreational and aesthetic uses and values. Authors suggested that intensive agriculture should be focused on lands where efficiency is greatest. Pressures on marginal agricultural land then could be reduced, making them available for conservation practices that contribute not only to onsite habitat improvement but also enhancement of downstream environmental quality.

Gard, N. W., M. J. Hooper, and R. S. Bennett. 1993. Effects of pesticides and contaminants on Neotropical birds. Pages 310-314 in D. M. Finch and P. W. Stangle, editors. *Status and management of Neotropical migratory birds*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-229. 422 pp.

Paper provided summary of potential effects of chemicals on migratory birds. Problems or effects of chemical applications and pollution remain difficult to assess; consequently, more is unknown than is known. Author recommended standardization of monitoring programs and selection of specific species as indicators.

Gatti, R. 1991. Evaluation of switchgrass nest cover for pheasants and ducks. Wisconsin Department Natural Resources, Madison. Project W-141-R, Final Report Study No. 127. 51 pp.

Pheasant and duck nest success was not consistently related to field size, shape, distance to water, cover height density, plant diversity, or cover type. Nest success was lower for nests closest to cover edges. Duck nest density was negatively related to plant diversity and positively related to height density of residual cover. Pheasant use was higher in fields with lower diversity of plant species, greater structural diversity, more irregular in shape, and further from water. Author concluded that widespread establishment of switchgrass nest cover and management of existing duck nest cover as monotypic stands of switchgrass was not justified based on costs, bird use, or nest success. He recommended management for diversity of cover types.

George, R. R., A. L. Farris, C. C. Schwartz, D. D. Humburg, and J. C. Coffey. 1979. Native prairie grass pastures as nest cover for upland birds. *Wildlife Society Bulletin* 7:4-9.

Lands seeded to pure stands of native grasses (switchgrass, Indiangrass, and big bluestem) that were properly managed as warm-season livestock forage, provided suitable nest cover for ring-necked pheasants and other upland nesting birds. In contrast, alfalfa and orchard grass hayfields produced no successful nests due to early season haying. Switchgrass was good cover because it maintained leaves, resisted burial by snow, and provided good residual spring cover. Passerine densities were highest in big

bluestem. Mixture of switchgrass, Indiangrass, and big bluestem was recommended for warm-season livestock forage and wildlife nesting cover. Little bluestem provided the best nesting cover, but it produced less forage and was more difficult to establish than other native grasses. Tall native grasses should not be grazed below 8-10 in. Grasses should be left undisturbed as much as possible in order to provide maximum residual cover in spring. Prescribed burns every 4-5 years will remove excess litter and prevent woody invasion.

Gerard, P. 1995. Agricultural practices, farm policy, and the conservation of biological diversity. U.S. Department of the Interior, National Biological Service. Biological Science Report 4. 28 pp.

Long-term declines in wildlife populations attributed to cropland expansion, agricultural intensification, and national farm policies. Where, when, and how crops are produced is influenced by social, economic, technological, and political factors. Close relationship between agricultural policy, land use practices, and wildlife populations illustrated by changes in prairie and Great Plains agricultural landscape and decline of grassland birds since the 1950s. Ability of CRP to slow or reverse population declines is limited by conflicting conservation objectives, voluntary nature of federal agricultural programs, and habitat requirements of affected species. Author maintains that biological conservation should be explicit objective of agricultural conservation policy. Additionally, full potential of CRP will only be realized when USDA works in partnership with conservation groups and conservation is decoupled from policies seeking to control commodity prices.

Gill, M., and S. Daberkow. 1991. Crop sequences among 1990 major field crops and associated farm program participation. U.S. Department of Agriculture, Economic Research Service, Agricultural Resources - Situation and Outlook Report. 24 October 1991.

Gillespie, G. W., and F. H. Buttel. 1989. Understanding farm operator opposition to government regulation of agricultural chemicals and pharmaceuticals: The role of social class, objective interests, and ideology. *American Journal of Alternative Agriculture* 4:12-21.

Report summarized results of a survey of farmers conducted in New York in 1982. Farmer opposition to government regulation of agricultural chemicals was primarily due to farmer ideology and was unrelated to farmers' experiences with chemicals. Farmer activities were increasingly affected by forces external to agriculture, including increased role of manufactured inputs into agricultural production. Farmers tended to have conservative socio-political orientation. They primarily were concerned about health and safety rather than environmental quality. In general, farmers were strongly opposed to regulation. Opposition to government

regulation was associated with farm size, proportion of income derived from farming, and level of concern about possible side effects of chemicals.

Gilpin, M., G. A. E. Gall, and D. S. Woodruff. 1992. Ecological dynamics and agricultural landscapes. *Agriculture, Ecosystems and Environment* 42:27-52.

Many parts of society see conflicts between conservation of biological resources and exploitation by agriculture. Agricultural production is essential to society. Agriculture also can provide stewardship for conservation of biological resources, but an interdisciplinary effort is needed for development of strategies that reward agriculture for good conservation. Agriculture and conservation are not mutually exclusive and can be positively linked on local, regional, and global scales. Governmental policies that support agriculture are often ineffective and underestimate true economic constraints.

Gliessman, S. R. 1984. An agroecological approach to sustainable agriculture. Pages 160-171 in W. Jackson, W. Berry, and B. Coleman, editors. *Meeting the expectations of the land: Essays in sustainable agriculture and stewardship*. North Point Press, San Francisco.

The strong ecological foundation upon which agriculture originally developed eroded as production systems became increasingly linked to economics. The author defined an agroecological approach as one that examines how agriculture can be more in balance with the natural environment and less dependent on costly inputs. Goal of this approach is to establish a framework or long-term sustainability of agricultural systems. Agricultural ecology is based on the premise that the short-term, mainly economic, focus of food production must be redirected toward long-term management systems based on cycles and interactions with natural systems.

Gould, J. 1991. Seasonal use of Conservation Reserve Program fields by white-tailed deer in eastern South Dakota. M.S. thesis. South Dakota State University, Brookings. 40 pp.

CRP lands were used by white-tailed deer in greater proportion to their availability during spring, summer, and fall. They selected CRP during active periods in the spring and summer and during bedding periods in summer and fall, but avoided CRP during fall active periods. CRP land provided important forage and cover in all seasons. Whereas maintenance mowing and weed control generally are detrimental to wildlife populations, CRP fields must have some type of disturbance every few years to maintain quality of habitat. Author recommended that maintenance of CRP fields occur every three to five years in late summer subsequent to nesting season. He concluded that management of CRP may not be optimal for wildlife, but it was superior to croplands that it replaced.

Granfors, D. A. 1992. The impact of the Conservation Reserve Program on eastern meadowlark production and validation of the eastern meadowlark Habitat Suitability Index model. M.S. thesis. Texas Tech University, Lubbock. 98 pp.

Eastern meadowlark productivity compared between CRP land and rangelands in Lyon County, Kansas. Nests in CRP fields had lower cowbird parasitism, larger clutch sizes, and higher hatch rates than nests in pastures. Cowbird parasitism appeared to be a major cause of lowered productivity of meadowlark nests. Eastern meadowlarks selected for less dense litter and more homogenous vegetation structure in both land use types. Nests in CRP fields had higher proportion of grass than was available in random sites. In CRP fields, residual cover was greater near nest sites than in sites not used for nesting.

Relationship between HSI values and eastern meadowlark densities was poor, because of high densities of meadowlarks in fields with high forb coverage. Relationships improved when HSI values and densities were averaged over the three years of the study. No discernible relationship between western meadowlark densities and the eastern meadowlark model were detected.

Granfors, D. A., K. E. Church, L. M. Smith. 1996. Eastern meadowlark nesting in rangelands and Conservation Reserve Program fields in Kansas. *Journal of Field Ornithology* 67:222-235.

Comparison of microhabitat, nest-site selection and nest success on Kansas rangelands and CRP. Daily nest survival rates and numbers fledged per female did not differ significantly between land use types. Mowing CRP fields was source of nest failure and induced adults to abandon some fields. CRP had significantly higher values for depth and density of litter cover, taller herbaceous canopy, less herbaceous cover, and more standing dead cover than rangelands. CRP has increased the diversity of available nesting habitats. Meadowlarks selected sites with greater litter cover, higher proportion of grass, more uncompacted litter, and more structural homogeneity than on random plots. Delay of mowing and burning recommended to enhance and maintain habitat suitability in CRP fields.

Mowing caused undesirable buildup of litter and, depending on time of year, may cause abandonment of fields and direct failure of nests. Consequently, partial mowing or spot mowing of fields after 15 July was recommended over complete mowing of field. Disadvantage of grazing is increased probability of trampling and attracting cowbirds. Prescribed burning can reduce litter and increase the proportion and vigor of native grasses while decreasing percentage of cool-season grasses and forbs. Although burning may cause temporary early-season loss in habitat quality, spring burning on three- or four-year rotation was recommended to maintain vigor of grass cover and reduce litter.

Graul, W. D. 1980. Grassland management practices and bird communities. Pages 38-47 in *Management of western forests and grasslands for nongame birds*. U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-86.

Grasslands contain relatively few bird species. However, there are many subtypes of grasslands that occur in a mosaic, and different species are restricted to different subtypes. Consequently, a general habitat category can contain considerably more species. Grassland bird communities tend to be numerically dominated by one or two abundant, widespread species. Grassland types contain species with extremely restricted habitat characteristics. Authors suggested that grassland management should be directed at providing habitat requirements of avian species with the most restrictive needs and maintain enough suitable habitat to support substantial numbers of the species. They assumed that species with broader habitat requirements would find suitable habitat.

Greenwood, R. J., A. B. Sargeant, D. H. Johnson, L. M. Cowardin, and T. L. Shaffer. 1987. Mallard nest success and recruitment in prairie Canada. *Transactions of the North American Wildlife and Natural Resources Conference* 52:298-308.

Study examined temporal and spatial variation in mallard nest success in prairie Canada. It identified causes of nest failure, determined species composition and densities of nest predators and estimated study area and overall recruitment rates. Authors observed much temporal and geographic variation. They determined that large native pastures containing brush were best duck nesting habitat in prairie Canada and recommended its protection.

Greenwood, R. J., A. B. Sargeant, D. H. Johnson, L. M. Cowardin, and T. L. Shaffer. 1995. Factors associated with duck nest success in the Prairie Pothole Region of Canada. *Wildlife Monograph* 128.

Study estimated nest initiation dates, habitat preferences, nest success, and nest fates for mallards, gadwalls, blue-winged teals, northern shovelers, and northern pintails nesting in Prairie Pothole Region of Canada. Nest success rate was most strongly associated with mallard production. Nest success varied both geographically and annually. Predators destroyed 72% of mallard, gadwall, blue-winged teal, and northern shoveler nests, and 65% of northern pintail nests. Nest success declined 4% for each 10% increase in cropland acreage, suggesting unstable local populations when cropland acreage exceeded 56% of available habitat.

Greenwood, R. J., A. B. Sargeant, J. L. Piehl, D. A. Buhl, and B. A. Hanson. 1999. Foods and foraging of striped skunks during the avian nesting season. *Wildlife Society Bulletin* 27:823-832.

Study of skunk food habits in Prairie Pothole Region of North Dakota during 1976-1978. Plant foods were of minor importance in spring and summer. Animal foods, primarily birds (including eggs), small rodents, and insects, were acquired exclusively in grasslands; proportion of animal (and insect) material in diet similar, irrespective of sex, season, or year. Sex and seasonal differences were detected in vertebrate foods. Bird and mammal foods declined in importance when wetland conditions were poor.

Griffin, S. L. 1991. Pronghorn use of agricultural land in northwestern South Dakota. M.S. thesis. South Dakota State University, Brookings. 63 pp.

Five percent of pronghorn observations were in CRP grasslands representing just 4% of the study area. Use of CRP often highest in early summer and winter when potential conflicts with agricultural interests were greatest. Timing and disproportionate use of CRP grasslands by pronghorns was interpreted as evidence that CRP may furnish high-quality foraging areas and thereby reduce depredation on small grain and alfalfa croplands. Future research should focus on better definition of pronghorn preferences for different grassland plantings permitted in program.

Gulinck, H. 1986. Landscape ecological aspects of agroecosystems. *Agriculture, Ecosystems and Environment* 16:79-86.

Discussion of the relevance of ecological concepts, especially landscape ecology, to agriculture. Author suggested that concept of landscape ecology may provide useful framework for reconciling human and environmental relationships.

Hall, D. L., and M. R. Willig. 1994. Mammalian species composition, diversity, and succession in Conservation Reserve Program grasslands. *The Southwestern Naturalist* 39:1-10.

Abundance of small mammals and species diversity were compared between native shortgrass grasslands and CRP fields in southern High Plains of Texas. CRP grasslands simulated shortgrass prairies in species diversity but not in species composition. CRP grasslands consisted of introduced grasses, primarily lovegrass, that allowed CRP to accomplish soil erosion goals but did not create "native habitat" with respect to plant or animal species composition. Successional changes in vegetational structure occurred in CRP sites. First-year sites on average contained more bare ground and less cover than older sites. Second-year sites were dense and almost homogenous with lovegrass. Third-year sites contained dense lovegrass, but it occurred in clusters or bunches interspersed with open spaces. In the first three years after establishment, diversity

of small mammals was similar in CRP grasslands and shortgrass prairie. Species composition may be highly dependent on specific physiognomic parameters that were not met in either agricultural sites or CRP grasslands. Authors indicated that mammalian species composition might be restored if grazing or fire disturbance were incorporated into long-term management of CRP grasslands.

Harmon, K. W. 1981. Future actions for management of private land wildlife. Pages 374-382 in R. T. Dumke, G. V. Burger, and J. R. March, editors. *Wildlife management on private lands*. Wisconsin Chapter of the Wildlife Society, Madison.

Harmon, K. W. 1987. History and economics of Farm Bill legislation and the impacts on wildlife management and policies. Pages 105-108 in J. E. Mitchell, editor. *Impacts of the CRP in the Great Plains*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-158.

Wildlife and economic considerations of long- and short-term land retirement contracts were compared. Author concluded that long-term contracts were better for pheasants and provided greater recreational and economic return.

Harris, B. L. 1991. Landowner options when CRP ends. Pages 24-26 in L. A. Joyce, J. E. Mitchell, and M. D. Skold, editors. *The Conservation Reserve - yesterday, today and tomorrow*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-203. 64 pp.

Paper outlined options available to landowners when their CRP contracts expired. Options included reenrollment in CRP, plowing grass to allow for rowcrop production, or maintenance of permanent grass cover for grazing or haying. Author anticipated that landowner decision would be strongly influenced by economics and that most of the expiring contracts would go back into crop production unless assistance was provided to encourage use as pasture. Author concluded that compensation was inadequate to prevent conversion back into cropland. He recommended that further development of CRP include incentives for farmers to retain grass cover on highly erodible lands.

Hays, R. L., and A. H. Farmer. 1990. Effects of the CRP on wildlife habitat: emergency haying in the Midwest and pine plantings in the Southeast. Transactions of the North American Wildlife and Natural Resources Conference 55:30-39.

The authors reported the preliminary results of 1988 sampling conducted in the Midwest region to determine the effects of the CRP on wildlife. The study objectives were to: (1) describe the conservation practices and vegetation of CRP fields; (2) describe trends in wildlife habitat resulting from CRP establishment; and (3) summarize the results for use in the development of the 1995 Farm Bill. Preliminary conclusions were that (1) vegetation establishment was progressing on CRP fields with weeds dominating; (2) CRP was already providing good nesting habitat for ring-necked pheasants and meadowlarks; (3) plantings of woody plants, food plots, and persistent herbaceous vegetation were encouraged for pheasants; and (4) mowing and haying likely affected pheasant and meadowlark nesting in 1988 and subsequently in 1989, year after mowing.

Hays, R. L., R. P. Webb, and A. H. Farmer. 1989. Effects of the Conservation Reserve Program on wildlife habitat: results of 1988 monitoring. Transactions of the North American Wildlife and Natural Resources Conference 54:365-376.

Highest amount of persistent vegetation cover was on CP2 (warm-season grasses) fields. Highest pre-green up average Visual Obstruction Reading was on CP2. Percentage of herbaceous cover made up of grasses was no different between conservation practices. CRP appears to be providing good nesting habitat for pheasants and fair nesting habitat for meadowlarks. Improvement in habitat quality for cottontails was not detected. Winter cover values appeared to be greater in CP2 than in CP1 (introduced grasses) stands. In northern areas, pheasant responses to CRP may be influenced by availability of winter food and cover. Authors recommended establishment of woody vegetation and food plots in areas where winter food and cover were limiting for pheasants.

Heimlich, R. E., and C. T. Osborn. 1993. After the Conservation Reserve Program: Macroeconomics and post-contract program design. Great Plains Agricultural Council Annual Meeting, June 2-4, 1993, Rapid City, South Dakota.

Heimlich, R., C. T. Osborn, and A. W. Allen. 1994. Including wildlife in an environmental benefits index (EBI) for analyzing alternative acreage reduction scenarios when CRP contracts expire. American Agricultural Economists Meeting, August 1993, Orlando, Florida. 8 pp.

Heimlich, R., C. T. Osborn, A. W. Allen, and R. Roath. 1994. What do we have to lose? Pages 13-15 in R. Clark, editor. Future use of Conservation Reserve Program lands in the Great Plains. University of Nebraska, Lincoln.

Henry, J. J. 1986. Ring-necked pheasant response to habitat improvements. Ohio Department of Natural Resources, Division of Wildlife. Federal aid in wildlife restoration final report for projects W-301-R-72 through R-92. 37 pp.

To maximize benefits of habitat improvements in intensive management areas, land use patterns and habitat deficiencies must be identified at township and section levels. Ideally, pheasant nesting cover should only be established in areas within one-quarter mile of secure winter cover. Minimum habitat goal should be improvement of 4% of area (25 acres/section or 900 acres/township).

Herkert, J. R. 1991. Prairie birds of Illinois: Population response to two centuries of habitat change. Illinois Natural History Survey, Bulletin from Symposium Proceedings: Our Living Heritage 34:393-398.

Herkert, J. R. 1994. Breeding bird communities of midwestern prairie fragments: The effects of prescribed burning and habitat area. Natural Areas Journal 14: 128-135.

Study compared the effects of habitat area and prescribed burning on breeding bird communities using midwestern prairie fragments. Habitat area had a much greater influence on the composition of the breeding bird community than prescribed burning. Large prairie fragments must be managed to provide a mosaic of burned and unburned areas to ensure that suitable habitat is available for species experiencing significant population declines and requiring large grassland areas. Benefits of burning include increase in above-ground plant biomass, which may provide greater nest concealment and reduced predation. Densities of insects were greater in burned than in unburned prairies. Management of large fragments of prairie is more complex than that of smaller fragments due to the presence of burn-sensitive species. The habitat requirements of burn-sensitive species can be addressed by providing a mosaic of habitat types. Author suggested that prescribed burns be conducted on large prairie fragments (> 80 ha) on three- to five-year rotation with 20-30% of area burned annually. On small fragments, a larger percentage may be burned, but < 50-60% of area should be burned annually, especially if burn-sensitive species are present.

Herkert, J. R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. *Ecological Applications* 4:461-471.

Study evaluated the effects of habitat fragmentation on midwestern grassland bird communities. Both area and vegetation structure significantly influence midwestern grassland bird communities. Species richness of breeding birds significantly increased with fragment size. Occurrences of eight of 15 bird species were influenced by habitat area. Estimates of minimal area requirements for five area-sensitive species ranged from five to 55 ha. Absence of area-sensitive grassland bird species from some small fragments may result from limited availability of habitat. All five area-sensitive species regularly avoided small grassland fragments that otherwise were suitable. Habitat fragmentation likely contributed to declines in area-sensitive grassland birds in the Midwest. Author recommended that management seek to minimize disturbances during the breeding season and control features, such as woody encroachment, that attract nest predators and brood parasites. Special attention given to area-sensitive species would be of general benefit to all grassland birds. Author cautioned that local or regional extinctions were likely if loss and fragmentation of grassland habitats continues in Midwest.

Herkert, J. R. 1998. The influence of the CRP on grasshopper sparrow population trends in the mid-continental United States. *Wildlife Society Bulletin* 26:227-231.

Author attempted to determine (1) whether CRP has had a measurable, widespread, population-level effect on population trends for grasshopper sparrows in the mid-continental United States, and (2) whether such trends were related to the amount of CRP in the local landscape. Analysis indicated that CRP had widespread, population-level influence on grasshopper sparrows in the mid-continental United States. BBS route slopes for grasshopper sparrows significantly increased from pre- to post-CRP periods. Differences in individual route slopes were related to local CRP enrollment.

Herkert, J. R., D. W. Sample, and R. E. Warner. 1996. Management of midwestern grassland landscapes for the conservation of migratory birds. Pages 89-116 in F. R. Thompson III, editor. *Management of midwestern landscapes for the conservation of Neotropical migratory birds*. U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, General Technical Report NC-187.

Avian species of high priority for conservation were associated with a variety of grassland habitats, including dry prairies, pastures, old fields, hayfields, wet prairies, sedge meadows, and grasslands with interspersed shrubs. Diverse habitat associations of bird species of high management concern suggested that problems facing grassland birds were widespread and involved a variety of

grassland habitats. One common feature was sensitivity to habitat fragmentation. Declines in grassland bird numbers significantly correlated with declines in regional acreages of pastures and hayfields. Nest success of grassland birds was highest two to three years following prescribed fire. Three- to five-year rotational burning appears to be optimum under most circumstances. Authors indicated that our understanding of winter ecology and habitat requirements of grassland bird species was incomplete. Relatively few avian species used fields with monotypic grass cover. Pastures were the region's most abundant grassland habitat accounting for 7.8 million ha or 5.7% of land area. Pastures provided important habitat because when they were not overgrazed, they supported diverse assemblages of grassland bird species, including those with declining populations. Pasture/hayfield acreage reached a peak in Midwest in early 1900s.

Large scale, diverse grassland management is needed to meet the habitat needs of migratory grassland bird species of the greatest conservation concern in Midwest region. Habitats of highest management concern will vary regionally. Management should focus on providing habitat for large populations of area-sensitive species to increase the likelihood of long-term persistence of populations.

Herman, R. J. 1993. Wildlife management on CRP. U.S. Department of Agriculture, Soil Conservation Service. Illinois Bulletin No. Ill90-3-33.

Higgins, K. F. 1987. Maintenance of planted grass stands for wildlife. *Proceedings of the North Dakota Academy of Science* 41:42.

Higgins, K. F., D. E. Nomsen, and W. A. Wentz. 1987. The role of the Conservation Reserve Program in relation to wildlife enhancement, wetlands, and adjacent habitats in the northern Great Plains. Pages 99-104 in J. E. Mitchell, editor. *Impacts of the Conservation Reserve Program in the Great Plains*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-158.

General treatments of anticipated wildlife-related benefits and problems associated with CRP in Great Plains. Potential uses of CRP grasslands after expiration of contracts were discussed. Authors recommended (1) following CRP standards during contract period, especially with respect to disturbance during the critical nesting period (Apr. 20-Aug. 1); (2) USDA action to encourage reenrollment in program; (3) enforcing mandatory standards for site-adapted/wildlife-friendly seeding mixtures; (4) encouraging wetland restoration on CRP lands; and (5) adopting compatible land uses.

Hoefer, P., and G. F. Bratton. 1987. The role of trees and shrubs as economic enterprises and wildlife habitat development in the Great Plains. Pages 109-112 in J. E. Mitchell, editor. Impacts of the Conservation Reserve Program in the Great Plains. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-158.

Authors maintain that trees and shrubs add performance to CRP and that there are measurable long-term economic and aesthetic advantages to tree planting for wildlife habitat. General information presented on CRP regulations for tree planting, roles of CP3 and CP5, and economic benefits of wildlife habitat development in CRP.

Homan, H. J., G. M. Linz, and W. Bleier. 2000. Winter habitat use and survival of female ring-necked pheasants (*Phasianus colchicus*) in southeastern North Dakota. American Midland Naturalist 143:463-480.

Study monitored winter habitat selection and survival of female pheasants in southeastern North Dakota. Relatively heavy snows forced pheasants from upland CRP grassland cover into cattail cover associated with large Class IV wetlands. CRP grasslands in study area often contained wetlands that became foci of wintering pheasants during milder periods of winter weather. CRP grassland cover became unsuitable in more severe snow periods when cover in upland and small, embedded wetlands became snow-packed.

Horn, D. J. 2000. The influence of habitat features on grassland birds nesting in the Prairie Pothole Region of North Dakota. Ph.D. dissertation. Iowa State University, Ames.

Study conducted in North Dakota Prairie Pothole Region examined how landscape composition influenced relations among (1) occurrence and abundance of grassland songbirds and field size, and (2) nest success of ducks, field size, and edges. Landscape composition influenced relations between field size and relative abundance of three grassland songbird species. As amount of grassland in landscape increased, the species abundance in smaller fields increased. Duck nest success increased with field size and was greater in study areas with 51-55% grassland than in 15-20% grassland. Positive relation between nest success and distance to edge in 50-51% grassland, but no relationship in 15-20% grassland.

Hubbard, M. W. 1991. Habitat changes in central Iowa and their relationship to ring-necked pheasant populations, 1981-1990. M.S. thesis. Iowa State University, Ames. 64 pp.

Study examined habitat changes in central Iowa and their relationship to ring-necked pheasant populations between 1981 and 1990. Habitat Suitability Index (HSI) model was evaluated by relating outputs to pheasant numbers using multiple regression. Pheasant numbers were negatively related to alfalfa/hay acreage and positively related to pasture lands. Area in roadside and spring VOR was positively related to pheasant numbers. Original HSI model lacked critical winter food element. Consequently, three variables: disked corn, chiseled corn, and disked soybeans were incorporated into the model. Widespread declines in pheasant populations in the northern Plains states since the 1960s were attributed to habitat loss associated with increased mechanization and conversion of noncrop acreage to croplands.

Hull, S. D. 1993. Avian, invertebrate, and forb abundance in Conservation Reserve Program fields in northeast Kansas with notes on avian behavior. M.S. thesis. Kansas State University, Manhattan. 141 pp.

Hull, S. D., R. J. Robel, and K. E. Kemp. 1996. Summer avian abundance, invertebrate biomass, and forbs in Kansas CRP. The Prairie Naturalist 28:1-12.

Comparison of invertebrate abundance in six Kansas CRP fields. Analysis did not detect significant relationships between forb abundance and invertebrate biomass or avian abundance, or between avian abundance and invertebrate biomass. Avian species richness did not vary with forb abundance. Authors suggested that findings did not support or reject commonly held assumption that increasing forb component in CRP fields planted to native grasses will enhance invertebrate biomass and avian abundance. Authors speculated that small sample size and low range of forb abundance in fields (0 to 23%) may have influenced study results and suggested that future studies increase number of fields sampled and range of forb abundance in fields sampled.

Hughes, J. P., R. J. Robel, K. E. Kemp, J. L. Zimmerman. 1999. Effects of habitat on dickcissel abundance and nest success in Conservation Reserve Program fields in Kansas. Journal of Wildlife Management 63:523-529.

Study examined the effects of habitat on dickcissel abundance and nest success in Kansas CRP fields dominated (95%) by Indiangrass, big bluestem, little bluestem, side-oats, switchgrass, and western wheatgrass. Dickcissel abundance was associated significantly with field-level vegetation characteristics, field edge characteristics, and land use surrounding CRP fields. Nest success was associated with field-level vegetation variables only, specifically those associated with vegetation volume. Daily nest survival was associated with

litter cover and live and dead canopy covers. Forbs have been recognized as preferred nesting substrates, but forbs were relatively uncommon in CRP fields evaluated in this study. Habitat quality of CRP fields might be enhanced for dickcissels by modifying vegetative characteristics of fields.

Hurley, R. J., and E. C. Franks. 1976. Changes in the breeding ranges of two grassland birds. *Auk* 93: 108-115.

Changes in the ranges of the dickcissel and horned lark were attributed to man-made environmental changes. Dickcissels were attracted to alfalfa, but this cover was a biological trap because harvesting typically coincided with prime nesting period.

Hurley, T. M., B. A. Babcock, R. E. Reynolds, and C. R. Loesch. 1996. Waterfowl populations and the Conservation Reserve Program in the Prairie Pothole Region of North and South Dakota. Iowa State University, Center for Agricultural and Rural Development, Working Paper 96-WP-165. 30 pp.

Study attempted to estimate CRP contributions to waterfowl conservation in the Prairie Pothole Region of North and South Dakota. Density of breeding pairs of waterfowl under current distribution of CRP was only 12.5% greater than what would have been realized if land had been randomly enrolled in the program. Authors suggested that old enrollment rules did a relatively poor job of targeting the best waterfowl habitat. They projected that improved targeting of CRP would double benefits for waterfowl. Additional benefits would be realized if priority was given to Wetland Management Districts that had quality waterfowl habitat. Benefits of such targeting would extend to other wildlife species as well as waterfowl. To maximize program benefits for wildlife, they recommended that targeting efforts focus on multiple county areas rather than regions.

Igl, L. D., and D. H. Johnson. 1995. Dramatic increase of Le Conte's sparrow in Conservation Reserve Program fields in the northern Great Plains. *Prairie Naturalist* 27:89-94.

Use of CRP fields by Le Conte's sparrows increased from 1990-1993 to 1994. Changes in the abundance of Le Conte's sparrows was associated with above normal precipitation from mid-1993 to mid-1994 that likely produced favorable breeding conditions for this species in CRP fields. Results suggested that the CRP fields may be important breeding habitat for species only under certain conditions (i.e., wet) and that use of these fields for emergency haying or grazing could negatively impact such species. Authors indicated that such impacts had not been studied sufficiently to draw any conclusions.

Igl, L. D., and D. H. Johnson. 1995. Migratory bird population changes in North Dakota. Pages 298-300 in E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. *Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems*. U.S. Department of the Interior, National Biological Service. Washington, D.C.

Review of the status and trends for 160 bird species recorded breeding in 128 quarter-sections located throughout North Dakota in 1967, 1992, or 1993. Authors summarized distribution of species by breeding habitat and migration strategy, number of indicated pairs by survey year for the 50 most abundant species, and number of indicated pairs by survey year, habitat, and migratory strategy.

Igl, L. D., and D. H. Johnson. 1999. Le Conte's sparrows breeding in Conservation Reserve Program fields: Precipitation and patterns of population change. *Studies in Avian Biology* 19:178-186.

Breeding Le Conte's sparrows were studied in CRP grassland from 1990 to 1996. Status changed from an uncommon breeding species to one of the most abundant species recorded in last two years of study. Results emphasized the importance of range-wide conservation efforts and long-term observations of grassland birds. In six-year study period, 111 species of birds were recorded using CRP grasslands during the breeding season. Dramatic increase in populations of this sparrow coincided with occurrence of wet conditions in the northern Great Plains. Authors concluded that geographically large conservation programs such as the CRP were important for long-term conservation of grassland birds.

Igl, L. D., and L. A. Murphy. 1996. CRP, succession, and Brewer's sparrows: Advantages of a long-term, federal land retirement program. *South Dakota Bird Notes* 48:69-70.

Isaacs, B., and J. D. Howell. 1988. Opportunities for enhancing wildlife benefits through the Conservation Reserve Program. *Transactions of the North American Wildlife and Natural Resources Conference* 53:222-231.

Based on a review of first five CRP sign-ups, the authors recommended that communication and cooperation between USDA and wildlife agencies be expanded and suggested that low-level, extensive wildlife habitat improvement would have greater benefits than intensive management on small acreages.

Jahn, L. R. 1988. The potential for wildlife habitat improvements. *Journal of Soil and Water Conservation* 43:67-69.

General discussion of multiple benefits of integrated agricultural and conservation programs.

Jahn, L. R., and E. W. Schenck. 1990. U.S. agricultural programs: Implications for wildlife and potential for improvement. Pages 359-371 in K. E. Church, R. E. Warner, and S. J. Brady, editors. *Perdix V: Gray partridge and ring-necked pheasant workshop*. Kansas Department of Wildlife and Parks, Emporia.

Jahn, L. R., and E. W. Schenck. 1991. What sustainable agriculture means for fish and wildlife. *Journal of Soil and Water Conservation* 46:251-255.

General discussion of potential Farm Bill contributions to sustainable agriculture and implications of the Farm Bill for fish and wildlife.

Jassen, L., M. Beutler, and T. Ghebremicael. 1994. Major characteristics of post-contract land use intentions for Conservation Reserve Program wetland tracts. South Dakota State University, Economics Staff Paper No. 94-2.

Jewett, G., C. C. Sheaffer, R. D. Moon, N. P. Martin, D. K. Barnes, D. D. Breitbach, and N. R. Jordan. 1996. A survey of CRP land in Minnesota: I. Legume and grass persistence. *Journal of Production Agriculture* 9:528-534.

Evaluation of vegetation in 151, six- to eight-year-old CRP fields planted to cool- and warm-season grasses in Minnesota. Legumes, mostly alfalfa and birdsfoot trefoil, persisted in 82% of CP1 field planted to legumes with 23% ground coverage. Authors recommended periodic mowing or development of persistent cultivars to maintain legumes in CRP fields. Alsike clover, red clover, and sweetclover did not persist in undisturbed fields.

Jewett, G., C. C. Sheaffer, R. D. Moon, N. P. Martin, D. K. Barnes, D. D. Breitbach, and N. R. Jordan. 1996. A survey of CRP land in Minnesota: II. Weeds on CRP land. *Journal of Production Agriculture* 9:535-542.

Evaluation of the prevalence of undesirable broad-leaved herbaceous plants (weeds) in 151, six- to eight-year-old CRP fields planted to cool- and warm-season grasses in Minnesota. Most prevalent weeds were Canada thistle, quackgrass, dandelion, and goldenrod. Cover of weeds was higher in CP10 fields than in CP1 or CP2 fields. Legume and grass groundcover usually was negatively correlated with weed groundcover. Authors indicated that widespread occurrence of noxious weeds in CRP fields was a cause for concern and should be addressed in future CRP planning.

Johnson, D. H., S. D. Haseltine, and L. M. Cowardin. 1994. Wildlife habitat management on the northern prairie landscape. *Landscape and Urban Planning* 28: 5-21.

Summary of European settlement impacts to northern prairie landscapes and wildlife habitat. Regional management of wildlife can not be effective on public lands alone. Partnerships with private landowners need to be developed. Wildlife managers need to base management activities on explicit, quantifiable objectives that furnish measures of survival, reproduction, and distribution of species. Descriptions of potential landscape-level management options were presented.

Johnson, D. H., and L. D. Igl. 1995. Contributions of the Conservation Reserve Program to populations of breeding birds in North Dakota. *Wilson Bulletin* 107:709-718.

Evaluation of projected changes in North Dakota breeding bird populations if CRP land was converted back to agricultural production. Of 18 species common on CRP, crop fields, or both, 12 were more abundant in CRP. Six of these species had suffered significant decline in populations. None of species common in cropland cover types had declined significantly. Termination of CRP and return of lands to cultivation projected to cause population declines for sedge wren, grasshopper sparrow, savannah sparrow, dickcissel, and lark bunting. The authors concluded that CRP not only provided important breeding habitat for grassland birds, but also may be a means to restore abundant populations of these species.

Johnson, D. H., and R. R. Koford. 1995. Conservation Reserve Program and migratory birds in the northern Great Plains. Pages 302-303 in E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. *Our living resources: A report to the nation on the distribu-*

tion, abundance, and health of U.S. plant, animal, and ecosystems. U.S. Department of the Interior, National Biological Service. Washington, D.C.

Presentation of nest densities and survival rates for selected common birds and waterfowl nesting in North Dakota and Minnesota CRP fields, croplands, and waterfowl production areas. Data supports conclusion that federal agricultural programs can have beneficial effects on wildlife resources over broad geographic areas. As CRP fields age, their attractiveness to certain species may change.

Johnson, D. H., and M. D. Schwartz. 1993. The Conservation Reserve Program: Habitat for grassland birds. *Great Plains Research* 3:263-295.

This paper discussed the grassland bird populations found in CRP fields in western Minnesota, North Dakota, South Dakota, and eastern Montana from 1990 to 1992. The study evaluated population responses of a number of grassland birds to different conservation practices established in CRP fields. In terms of overall breeding bird densities, no one conservation practice was found to be uniformly better than another. Particular cover practices favored certain species. The authors concluded that CRP fields provided habitat for a wide array of grassland birds and that CRP had the potential to reverse the population declines for several species.

Johnson, D. H., and M. D. Schwartz. 1993. The Conservation Reserve Program and grassland birds. *Conservation Biology* 7:934-937.

Authors evaluated breeding bird use of CRP fields in North Dakota, South Dakota, eastern Montana, and western Minnesota during the 1990 and 1991 nesting seasons. They compared their findings with trends from Breeding Bird Survey records for 1966 through 1990. They recorded 73 bird species using CRP fields. The most abundant birds, in order of abundance, were lark bunting, grasshopper sparrow, red-winged blackbird, western meadowlark, and horned lark. Several prairie bird species declining in abundance from 1966 to 1990 were common in CRP fields. Early results suggested that restored grasslands were supporting a wide variety of grassland birds, some of which had experienced dramatic declines in the past 30 years.

Johnson, G. J., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. *Journal of Wildlife Management* 54:109-111.

Rates of nest predation and brood parasitism for five species of birds nesting in fragments of tallgrass prairie in Minnesota were affected by the size of the prairie fragment, distance to wooded edge, and number of growing seasons since vegetation around nest was last burned. Rates of nest predation were reduced in larger

habitats, away from wooded edges, and in vegetation burned less than three years. Management to maximize nest productivity should focus on provision of large fields, regular burning, and removal of wooded edges. Species investigated included clay-colored sparrow, savannah sparrow, bobolink, grasshopper sparrow, and western meadowlark. Because of increased abundance of cowbirds and addition of wooded edges to prairie habitat, nest productivity of prairie nesting birds may be declining. Authors speculated that tall, dense vegetation in recently burned prairies reduced visibility of nests and restricted predator movements. Additionally, increased production of seeds and insects in recently burned areas may have reduced time spent foraging and increased time available to attend nests.

Johnson, R., E. Ekstrand, J. R. McKean, and K. John. 1994. The economics of wildlife and CRP. Pages 45-51 in *When Conservation Reserve Program contracts expire: The policy options*. Soil and Water Conservation Society, Ankeny, Iowa.

Author stated that net taxpayer outlay was one way to evaluate the cost effectiveness of the CRP. Reduced farm production expenditures from CRP have raised some concerns for local rural communities. The author suggested that negative economic impacts were partially offset by increases in wildlife-related economic activities such as hunting, bird watching, or fishing. The author determined that taxpayer outlay for the first 11 CRP sign-ups was \$8.9 billion; wildlife economic benefits totaled \$8.6 billion, and total benefits (including water quality) was \$13.4 billion. The author concluded that CRP was economically beneficial for participating producers and society.

Johnson, R. G., and S. A. Temple. 1986. Assessing habitat quality for birds nesting in fragmented tallgrass prairies. Pages 245-249 in J. Verner, M. L. Morrison, and C. J. Ralph, editors. *Wildlife 2000: Modeling habitat relationships of terrestrial vertebrates*. University of Wisconsin Press, Madison.

Johnson, R. J., and M. M. Beck. 1988. Influences of shelterbelts on wildlife management and biology. *Agric. Ecosystems Environ.* 22/23:301-335.

Comprehensive review of bird and mammal use of shelterbelts as shelter, escape or refuge cover, foraging sites, reproductive habitat, and travel corridors. Shelterbelts have contributed to range expansion of some small mammals and birds. Numbers and diversity of wildlife were positively correlated with area, perimeter length, adjacent land uses and vegetative diversity and complexity. Authors concluded that practice provided economic, educational, recreational, and aesthetic benefits with minimal wildlife damage or nuisance problems to adjacent areas.

Johnson, R. L., J. R. McKean, C. L. Sandretto. 1992. Increased recreational hunting can offset negative economic impacts of the Conservation Reserve Program. U.S. Department of Agriculture, Economic Research Service/Technical Bulletin TB92-4. 23 pp.

Analysis of National Survey of Fishing and Hunting data for northeastern Colorado estimated the increase in small game and migratory bird hunting needed to offset negative economic effects of the CRP. Authors estimated that income from recreational uses would need to increase 1.8- to 2.5-times to offset negative economic effects of the CRP. Adverse economic impacts of CRP would sharply increase if participants left the region.

Jones, L. A., and A. D. Kruse. 1995. The northern Great Plains - Wildlife goals and objectives for the 1995 Farm Bill. Transactions of the North American Wildlife and Natural Resources Conference 60:307-314.

Authors provided general review of land use changes since settlement and impacts of these changes on bird populations in northern Great Plains. Regional goals were presented for selected wildlife groups (waterfowl, other wetland birds, gray partridge, pheasants, prairie grouse, raptors, nongame birds, fisheries, and big game) and grassland, wetland, and riparian aquatic habitats.

Joyce, L. A., J. E. Mitchell, and M. D. Skold, editors. 1991. The Conservation Reserve - yesterday, today and tomorrow: Symposium. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-203. 64 pp.

Proceedings of symposium held in conjunction with the Society of Range Management. Topics were wide-ranging, following themes of CRP impacts on people and resources in 10 Great Plains states where 50% of program is located.

Joyce, L. A., and M. D. Skold. 1987. Implications of changes in the regional ecology of the Great Plains. Pages 115-127 in J. E. Mitchell, editor. Impacts of the Conservation Reserve Program in the Great Plains. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-158.

Paper examined CRP in context of environmental, economic, and ecological changes in Great Plains. Authors concluded that (1) benefits of retiring Great Plains cropland for soil erosion were

reduced compared to other regions; (2) 10-yr contracts were more beneficial for wildlife than annual diversions and conservation compliance measures; and (3) impact of CRP (up to 20 million acres) will be dwarfed by future land use changes that will result in 100 million acres being taken out of production in Great Plains by 2000.

Just, R. E., and J. M. Antle. 1990. Interaction between environmental and agricultural policies: Opportunities for coordination and limitations for evaluation. *American Economic Review* 80:197-202.

Agricultural policy has had a well-documented impact on farmers' production decisions, which in turn has affected the environment. The public's perception is that existing agricultural policies are linked to agricultural pollution. Existing agricultural and environmental policies can have either positive or negative effects on non-point source pollution. Agricultural policy can be used to mitigate pollution if properly implemented. Agricultural production and environmental impacts depend on site-specific environmental conditions. Authors concluded that generalizations about the environmental impacts of agricultural policies were easy to make but that they should be avoided.

Kantrud, H. A. 1981. Grazing effects on avifauna of North Dakota. *Canadian Field-Naturalist* 95:404-417.

Avian species richness tended to decrease in response to greater grazing intensity, but total bird density increased due to higher populations of a few species. Total bird density was always highest on idle or lightly grazed sites. In general, distribution and abundance of most grassland bird species in North Dakota have been negatively affected by agricultural and pastoral activities. Fragmentation of grasslands by agriculture resulted in extirpation of some species; effects of cultivation on grassland birds have been greatest in the eastern tallgrass prairie region where extensive habitat loss has occurred. Author advocated protection for remaining areas of grassland representative of the region. Periodic management will be required for long-term preservation.

Kantrud, H. A. 1993. Duck nest success on Conservation Reserve Program land in the Prairie Pothole Region. *Journal of Soil and Water Conservation* 48: 238-242.

Duck nest success was higher (23.1%) on CRP tracts than on Waterfowl Production Areas (8.2%). Larger field size, greater distance from water, lower nest densities, and good vegetative cover on CRP fields contributed to lower rates of predation.

Kantrud, H. A., and K. F. Higgins. 1992. Nest and nest site characteristics of some ground-nesting, non-passerine birds of northern grasslands. *Prairie Naturalist* 24:67-84.

Fields with numerous wetlands were more attractive to upland-nesting shorebirds than were similar fields where wetlands were more distant. All species studied used native grassland for nesting. Fourteen species nested in seeded grasslands and croplands. Nest success rates did not differ among habitat types for any species. Except for killdeer, few nests were in annually tilled croplands. Recommendations for pasture management of mixed-grass prairies in North Dakota were provided.

Kantrud, H. A., and R. L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains. U.S. Fish and Wildlife Service. Wildlife Research Rept. 15. 32 pp.

Livestock grazing on lands set aside for wildlife can be used as a management measure to increase populations of game species and increase diversity of plant or animal species. Light to moderate grazing resulted in increased species richness. Species richness was significantly reduced by heavy grazing in the northern Great Plains. Grazing by domestic livestock generally decreased average vegetative height and increased exposure of bare soil; in lightly grazed plots, height of vegetation seemed to decrease because of shading effect of large amounts of litter. Increased richness was associated with plots in which the height of vegetation was not appreciably reduced and the percentage of bare soil not greatly increased by excessive grazing.

Kaufman D. W., and G. A. Kaufman. 1989. Nongame wildlife management in central Kansas: implication of small mammal use of fencerows, fields, and prairie. *Transactions of the Kansas Academy of Science* 92: 198-205.

Prairie-cropland ecotone provides suitable habitat for several native small mammals. Fencerows between prairie and cropland supported an abundant, diverse assemblage of native small mammals. The association of these species was apparently dependent on tall, dense vegetation, deep litter, and ready access to food in cropfields. Interiors of cropland, even when fallow, were insufficient to support most species of small mammals. Establishment of small ungrazed herbaceous and woody habitats scattered within the matrix of cultivated fields would enhance small mammal density and diversity.

Keeland, B. D., J. A. Allen, and V. V. Burkett. 1995. Southern forested wetlands. Pages 216-218 in E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. *Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems*. U.S. Department of the Interior, National Biological Service. Washington, D.C.

Review of presettlement conditions, current status, causes of loss, and future prospects for forested wetlands in southern United States.

Kelly, C. R., and J. A. Loden. 1995. Federal farm program conservation initiatives: Past, present, and future. *Natural Resources & Environment* 9:17-19.

From its New Deal beginnings, farm policy has been primarily designed to stabilize commodity prices and to support farm income. Natural resources capital on which agriculture is dependent has not been the primary concern of those who have guided federal farm policy for the past 60 years. Conservation initiatives have largely served to gain political support or otherwise assist in achieving a given program's economic objectives. Although economic well-being will always be the predominant concern of federal policy, conservation is likely to assume greater importance. Budgetary constraints and international competition will accelerate market-orientated policies. Paying farmers for adopting conservation practices is likely to expand, replacing other mechanisms for supporting farm income.

Authors discussed politics associated with green payments; namely, favored recipients of green payments are not likely to be the same farmers favored by current income transfers. Program may not provide benefits to small farmers because attention may be directed at those who farm the most land. Also, income from green payments may be insufficient to interest farmers.

Kennedy, C. L., and K. F. Higgins. 1995. Effects of grazing on nongame breeding birds, insects, and vegetation in Conservation Reserve Program grasslands in North Dakota. *Annual Meeting of the Society of Range Management* 48:32-33.

Kessler, W. B., H. Salwasser, C. W. Cartwright, Jr., and J. A. Caplan. 1992. New perspectives for sustainable natural resources management. *Ecological Applications* 2:221-225.

Management of public lands and resources requires that managers (1) respond to more complex views of public lands and their roles in meeting human needs and aspirations; (2) define objectives that relate to ecological and aesthetic conditions of the land and desired future condition of public lands necessary to sustain land uses and resource yields; (3) recognize that grasslands are sustainable in nature by dynamic forces such as fire, flood, and grazing. (These forces continually change vegetation patterns and processes having major effects on biological diversity, water quality, and other values.)

The public must be fully informed about the conditions, capabilities, and options for lands and resources and share in knowledge that professionals accrue through research and management experience. Science must take into consideration the values and needs of people rather than concluding what is good or bad for society from their own technical perspectives. Changes in perspectives must address cumulative effects of management and landscape fragmentation. Ecosystems must be looked at as a whole rather than individual parts.

Kimmel, R. O., A. H. Berner, R. J. Welsh, B. S. Haroldson, and S. B. Malchow. 1992. Population responses of gray partridge (*Perdix perdix*), ring-necked pheasants (*Phasianus colchicus*), and meadowlarks (*Sturnella* spp.) to farm programs in Minnesota. *Giber Fauna Sauvage* 9:797-806.

King, J. W. 1991. Effects of the Conservation Reserve Program on selected wildlife populations in southeast Nebraska. M.S. thesis. University of Nebraska, Lincoln. 39 pp.

Study conducted in southeast Nebraska compared wildlife populations areas with high and low CRP enrollments. Pheasant population showed a positive response to nesting, loafing, and roosting cover furnished by CRP plantings. CRP grasslands enhanced habitat quality for nongame birds by providing nesting and brood-rearing cover in agricultural landscapes where such cover was absent prior to the program. Effects of CRP on eastern cottontail populations unclear. Author speculated that habitat quality for nongame birds would decline in CRP grasslands planted to single species of grass as they matured. He recommended periodic disturbance (e.g., burn every three to five years) of CRP fields to maintain desirable features of vegetation composition.

King, J. W., and J. A. Savidge. 1995. Effects of the Conservation Reserve Program on wildlife in southeast Nebraska. *Wildlife Society Bulletin* 23:377-385.

Pheasant numbers in southeastern Nebraska were higher in areas with approximately 20% CRP enrollment than in areas with < 5% CRP enrollment. Meadowlark numbers and cottontail numbers did not differ between areas. No differences were found between numbers of birds or avian richness between cool-season and warm-season cover types. Author interpreted the lack of a relationship between bird numbers and vegetation diversity as evidence that vegetative structure and amount of cover were more important than plant diversity. Vegetation generally was taller in warm-season than in cool-season plantings. Author suggested that fields be burned every three to five years. Habitat quality of fields seeded with a single grass species generally declined as vegetation matured and became more dense.

Kirsch, L. M., H. F. Duebbert, and A. D. Kruse. 1978. Grazing and haying effects on habitat of upland nesting birds. *Transactions of the North American Wildlife and Natural Resources Conference* 43:486-497.

Extensive review of effects of grazing and haying on upland nesting ducks, game birds, and nongame birds. Strong positive relationships between height-density of undisturbed vegetation and duck nest densities and nesting success demonstrated for North Dakota study site. Authors strongly recommended against annual grazing and haying.

Klett, A. T., H. F. Duebbert, and G. L. Heismeyer. 1984. Use of seeded native grasses as nesting cover by ducks. *Wildlife Society Bulletin* 12:134-138.

Study conducted in North Dakota (1970-1973) compared duck nesting activity in unplowed native prairie to fields seeded native grasses or introduced grasses and legumes. Nest survival did not vary among cover types, but nest density was reduced in native prairie compared to native and nonnative plantings.

Klett, A. T., T. L. Shaffer, and D. H. Johnson. 1988. Duck nest success in the Prairie Pothole Region. *Journal of Wildlife Management* 52:431-440.

Nesting success estimated for five species of dabbling ducks nesting in eight habitat types in the Dakotas and Minnesota, 1964-1984. Nesting success rates ranged from < 5 to 36%, but varied among regions, periods, and species. Nests located in idle grassland were most successful; cropland nests were least successful. Mammals were major cause of nest failure, but farming operations resulted in 24% loss in haylands and 37% loss in cropland. Observed recruitment rates generally were below levels necessary to sustain populations.

Klute, D. S. 1994. Avian community structure, reproductive success, vegetative structure, and food availability in burned CRP fields and grazed pastures in north-eastern Kansas. M.S. thesis. Kansas State University, Manhattan. 168 pp.

Study compared avian community structure and reproductive success, vegetative structure, and food availability in CRP fields with native grasslands that were burned and grazed. During summer, the relative abundance of avian species was greater in grazed native grasslands than in CRP fields. Differences in bird communities were attributed vegetative characteristics. Specifically, vegetative height and biomass (VOR) were greater in CRP than grazed native grasslands. Total invertebrate biomass during summer was significantly greater in grazed native grasslands than in CRP. Author suggested that high invertebrate abundance was related to greater forb coverage in grazed native grasslands. During winter, relative avian abundance did not differ between CRP and grazed native grasslands, but species richness greater in CRP that had taller vegetation and more bare ground than grazed native grasslands. Total biomass of available seed did not differ between CRP and grazed native grasslands; however, CRP contained more preferred food items. Author concluded that CRP provided better winter habitat. He suggested that moderate grazing, contributing to reduced vegetative height, increased total canopy coverage, and increased forb coverage, may improve CRP fields for grassland birds.

Klute, D. S., and R. J. Robel. 1993. Comparative avian usage of rowcrop, burned and unburned CRP fields, and grazed pastures in eastern Kansas. *Horned Lark* 20:4 (abstract only).

Klute, D. S., R. J. Robel, and K. E. Kemp. 1997. Seed availability in grazed pastures and Conservation Reserve Program fields during winter in Kansas. *Journal of Field Ornithology* 68:253-258.

Study compared seed abundance in CRP fields and grazed native pasture in Kansas in winter. Seed abundance in CRP fields differed between winters and changed seasonally; biomass was greater than that in grazed pasture in one of two years. Authors concluded that CRP fields were superior to grazed native grasslands as winter habitat for birds.

Knopf, F. L. 1986. Changing landscapes and the cosmopolitanism of the eastern Colorado avifauna. *Wildlife Society Bulletin* 14:132-142.

Development of riparian forests on the Great Plains has provided corridors for movement of forest birds across grasslands that have historically served as ecological barriers to their dispersal. This example illustrates the relevance of current conservation theory to decisions on local management and the need for regional management plans.

Knopf, F. L. 1988. Conservation of steppe birds in North America. ICBP Technical Publication No. 7: 27-41.

Only nine avian species are wholly endemic to the tall- and shortgrass prairies. An additional 19 species have strong affinities to the grasslands but also occur in adjacent vegetation types. Endemic species spend entire year within the grassland; the remaining species tend to migrate into brushland and other habitats in Mexico and Central America. About 260 species of birds regularly breed in the grasslands of North America; however, most are associated with wetlands or man-altered landscapes. Locally, bird communities within grassland average only three to five species during the breeding season with substantial seasonal and annual variation in densities. Invasion of steppe by woody plants provides habitat for birds more typical of eastern deciduous forests; mixing of avifaunas has occurred at the potential expense of primary and most secondary species of steppe birds. Land acquisition programs should identify the needs of the area-sensitive stenotopic species for a site when planning steppe purchases.

Knopf, F. L. 1992. Faunal mixing, faunal integrity, and the biopolitical template for diversity conservation. *Transactions of the North American Wildlife and Natural Resources Conference* 57:330-342.

At many locations, local species assemblages have been affected by the addition of new species from contiguous or distant sites. Often augmented faunas are viewed positively by the public and management agencies, but shifts in the composition of native biological diversity can lead to declines in regionally unique species. Faunal mixing is a dilemma for biologists dedicated to protecting the integrity of native, endemic faunas. Dichotomy exists for managers between preserving the biological diversity of and enhancing vertebrate populations. Traditional policies of natural resource agencies have favored the spread of ecological-generalist species across landscapes. Most popular game species are characteristic of early successional habitats. These species typically respond favorably to greater edge and habitat diversity. Enhancing species richness through fragmentation in landscape is no longer favored and growing evidence suggests that increasing the quantity of edge can harm the composition of some wildlife communities. Ecological consequences of species substitutions are masked in management that focuses purely on species richness. Conservation of biological diversity must complement the conservation of endangered species. Despite the extinction of many species and a general decline in the biological diversity of North America, many local faunas contain more species today than historically present. Species introductions and range expansions into altered landscapes have augmented local species richness. Future conservation of faunal integrity requires enhanced coordination among natural resource agencies.

Knopf, F. L. 1994. Avian assemblages on altered grasslands. *Studies in Avian Biology* 15:247-257.

During last 25 years, grassland bird species have shown steeper, more consistent, and geographically widespread declines than any other behavioral or ecological guild of North American birds. Unlike forest species that winter in the Neotropics, birds that breed in North American grasslands also winter on the continent. Thus, problems driving declines in grassland species are associated almost entirely with North American processes, especially loss and degradation of North American grasslands.

Knopf, F. L., and F. B. Samson. 1992. Conserving the biotic integrity of the Great Plains. Pages 121-133 in S. R. Johnson and A. Bouzaher, editors. *Conservation of Great Plains ecosystems: Current science, future options*. Kluwer Academic Press, Dordrecht, The Netherlands.

Despite the relatively simplistic composition of the endemic avifauna in the Great Plains, endemic species are currently showing steeper, more consistent, and geographically widespread declines than any other group of North American birds. For example, 10 of 32 grassland bird species have declined at statistically significant rates from 1966 to 1991. Processes that shaped endemic plant and animals on the Great Plains were drought, grazing, and wildfire. These factors favored broad expanses of monotypic vegetation with minimization of ecological edges. Activities that have had universal effects on native diversity include fragmentation of grasslands, drainage of wetlands, invasion or introductions of alien and exotic species, and construction of water development activities. Impoundment of rivers and elimination of natural fire regimes has had severe consequences to native flora and fauna of the western Great Plains. Ninety percent of bird species presently breeding in northeastern Colorado did not breed there at the turn of the century.

Knopf, F. L., and M. L. Scott. 1992. Altered flows and created landscapes in the Platte River headwaters, 1840-1990. Pages 70-74 in J. M. Sweeney, editor. *Management of dynamic ecosystems*. The Wildlife Society, North Central Section, West Lafayette, Indiana.

Impoundment has severely reduced annual runoff peaks and total discharge in the Platte River. The Platte's deciduous gallery forest provides local habitats for more wildlife species than occurred historically in the headwaters. Unique characteristics of riparian ecosystems are the pulsed flow resulting from spring runoff and linear connectivity across elevational gradients. Stabilization of hydrodynamic regimes in headwater streams has drastically altered the characteristic fluvial processes that shaped these ecosystems. Annual floods with high sediment loads tended to maintain wide, shallow, and active river channels. Changes in hydrology can be attributed to removal of beaver, changes in upland land uses, and water developments for agriculture, municipal, and industrial uses.

Woody vegetation on pristine rivers consisted of widely scattered stands of cottonwood and willows. Hydrologic conditions controlled the patterns of establishment and growth of woody riparian species. Increased summer flows have been the driving ecological force in Platte River and have enabled dramatic movements of faunal assemblages at the local and regional level. Connectivity provided by the riparian corridor has allowed western expansion of species such as white-tailed deer, fox squirrel, and numerous birds and small mammals.

Koford, R. R. 1999. Density and fledgling success of grassland birds in Conservation Reserve Program fields in North Dakota and west-central Minnesota. *Studies in Avian Biology* 19:187-195.

CRP fields were suitable breeding habitat for several species whose populations declined prior to program. Habitat furnished appeared to be as secure as other suitable habitats in federal Waterfowl Production Areas within these states. Additional cover provided by CRP may have lowered breeding densities in all habitats with possible benefits if reproduction was density dependent. Additional habitat also may have allowed some birds (e.g., second-year birds) to breed that otherwise would not have bred, thereby supporting higher growth of populations.

Koford, R. R., and L. B. Best. 1996. Management of agricultural landscapes for the conservation of Neotropical migratory birds. Pages 86-88 in F. R. Thompson III, editor. *Management of midwestern landscapes for the conservation of Neotropical migratory birds*. U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, General Technical Report NC-781.

Thirty-eight Neotropical migratory birds are common in Midwest agricultural landscapes. Most of these species depend on herbaceous or wooded habitats that have declined as average size of farms has increased. Immediate effect of tillage is exposure of arthropods and other prey to foraging birds; long-term effect is reduction in abundance of litter-dwelling arthropods. Conventionally tilled fields had lower arthropod abundance than no-till or idle areas. Herbicides affected birds by reducing availability of seeds. Insecticides reduced abundance and diversity of foliage-dwelling arthropods. Strip cover, such as grassed waterways, terraces, fencerows, roadsides, and windbreaks/shelterbelts, usually provide stable habitat. Strip cover has decreased in recent years. Bird use of grassed waterways was influenced by orientation of buffer relative to crop rows: nest densities were greater when rows were parallel to waterways. Authors provided numerous recommendations for management of habitats for birds in agricultural landscapes.

Kramer, C. S., B. J. Elliott, L. M. Rubey, and G. E. Rossmiller. 1989. The political economy of U.S. agriculture: Challenges for the 1990s. Pages 267-281 in C. S. Kramer, editor. The political economy of U.S. agriculture: Challenges for the 1990s. National Center for Food and Agricultural Policy, Resources for the Future. Washington, D.C.

Krapu, G. A., P. J. Pietz, D. A. Brandt, and R. R. Cox. 2000. Factors limiting mallard brood survival in prairie pothole landscapes. *Journal of Wildlife Management* 64:553-561.

Evaluation of the effects of percent of seasonal basins holding water, percent of upland landscape in perennial cover, rainfall, daily minimum ambient temperature, hatch date, brood age, age of brood females, and brood size on mallard brood survival in prairie pothole landscape. Final fitted model contained only main effects of percent of seasonal basins holding water, rainfall, and hatch date. Authors recommended maintenance of seasonal wetlands as major component of wetland complexes and management for enhanced success of early laid clutches.

Kurzejeski, E. W. 1996. Vegetation structure and avian species composition in diverted farmland. Missouri Department of Conservation, Federal Aid Project No. W-31-R-05, Final Report. 75 pp.

Comparison of vegetative conditions, avian abundance, composition, and productivity on CP1, CP2, and rowcrop fields in northern Missouri. Total bird abundance, grassland bird abundance, nest density, and number of nesting species were lower on croplands than on CRP fields. Bird community using crop fields differed from that of CRP fields with shortgrass and open-ground feeding birds most common on crop fields. The conservation value of CRP fields for declining grassland bird species was higher for CP1 fields than CP2 fields. To increase the potential wildlife benefits of CRP and other idle grassland habitats, monotypic stands of either warm-season or cool-season grasses should be avoided. Because litter buildup and accelerated grass succession may negatively affect wildlife values of fields, authors recommended periodic haying and grazing of diverted farmlands. They also recommended that cost sharing of grass plantings should be limited to multi-species seedings.

Kurzejeski, E. W., L. W. Burger, Jr., M. J. Monson, and R. Lenkner. 1992. Wildlife conservation attitudes and land use intentions of Conservation Reserve Program participants in Missouri. *Wildlife Society Bulletin* 20:253-259.

Survey of CRP participants in Missouri to determine their attitudes toward wildlife conservation and intended uses of CRP lands. Sixty-two percent of respondents indicated wildlife was an important consideration in choice of farming practices. Only 9.4% of all respondents enrolled land in permanent wildlife habitat. Fifty-six percent of respondents indicated that they were unaware of this practice. Authors recommended increased educational efforts to promote wildlife management options should target both landowners and administering agencies.

Lambert, J. D., and S. J. Hannon. 2000. Short-term effects of timber harvest on abundance, territory characteristics, and pairing success of ovenbirds in riparian buffer strips. *Auk* 117:687-698.

Study compared abundance, territory characteristics, and pairing success of area-sensitive songbirds in 20, 100, and 200 m riparian buffer strips in boreal mixed-wood forest in Alberta. Ovenbirds were absent from 20 m buffers. Abundance and territory size were unaffected by harvest. Females were attracted by males in both buffer widths. Authors concluded that 100 and 200 m buffers retained ovenbirds during year following harvest but that long-term monitoring of harvest effects was needed.

Langer, L. L. 1989. Land use changes and hunter participation: The case of the Conservation Reserve Program. *Transactions of the North American Wildlife and Natural Resources Conference* 54:382-390.

Paper provided general review of Farm Bill effects on agricultural land use and wildlife habitat by region. Author provided regional estimates additional income derived from hunting on CRP lands. Overall value of hunting benefits from CRP between 1986 and 2000 was estimated to be \$3.8 billion.

Lauber, B. 1991. Birds and the Conservation Reserve Program: A retrospective study. M.S. thesis. University of Maine, Orono. 252 pp.

Analysis of county-level estimates of bird population density data obtained from Breeding Bird Survey and land use statistics. CRP appeared to provide benefits for selected populations of avian species. Thirty-one of 102 species tested were correlated with CRP distribution. Four species (western meadowlark, ring-necked pheasant, brown-headed cowbird, northern bobwhite) showed evidence of positive population responses to CRP establishment. Study was completed during early years of CRP (1986-1988) when enrollment was relatively low and vegetative characteristics reflected early composition and structure of CRP plantings.

Leddy, K. L., K. F. Higgins, and D. E. Naugle. 1999. Effects of wind turbines on upland nesting birds in Conservation Reserve Program grasslands. *Wilson Bulletin* 111:100-104.

CRP grasslands without turbines and areas located 180 m from turbines supported densities of grassland birds four-times higher than areas within 80 m of turbines. Authors recommended that turbines be placed in cropland that support lower densities of grassland passerines than those found in CRP grasslands. Human disturbance, noise, and physical movements of turbines may have disturbed nesting birds.

Lee, C. D. 1995. Wildlife needs of the southern Great Plains for the 1995 Farm Bill discussions. *Transactions of the North American Wildlife and Natural Resources Conference* 60:315-319.

General description of benefits of Farm Bill to wildlife in the region and projected effects on wildlife if program was not reauthorized. Strategies outlined for following Farm Bill provisions: Conservation Compliance, CRP, Water Quality Improvement Program, Stewardship Incentive/Forest Incentive Programs, WRP and Water Bank, Agricultural Conservation Programs and Great Plains Contracts, Acreage Conservation Reserve, Total Farm Management Program, Riparian Corridor Program, and Wildlife Conservation Reserve Programs. Social benefits of Farm Bill program were identified.

Lewis, T. 1969. The diversity of insect fauna in a hedgerow and neighboring fields. *Journal of Applied Ecology* 6:453-458.

Hedgerows contributed to enriched insect fauna in neighboring fields. In terrestrial insect communities, diversity was greatest in hedges, lower in beans, and least in pasture. Diversity of aerial insects decreased with increasing distance from the hedge. Presence of hedge enriched aerial insect population for a distance of 10-times hedge height on the downwind side to one- to two-times hedge height on the upwind side.

Lichtenberg, E., and R. Zimmerman. 1999. Information and farmers' attitudes about pesticides, water quality, and related environmental effects. *Agriculture, Ecosystems and Environment* 73:227-236.

The effect of agricultural activities on environmental quality depends upon the behavior of farm operators. Farmers' beliefs are similar to those of the general public on average, but may be more polarized on environmental issues. Relationship between information and farmers' beliefs about environmental quality and compliance with environmental protection measures is complex. Effects of information depend both on the form in which the information is

presented and on farmers' attitudes toward the sources presenting the information. Beliefs can influence the kind of information selected, receptivity, and how relevant farmers consider the information in affecting decision-making. Farm magazines are a frequent source of information followed by NRCS and extension agents. Extension services and institutional sources of information rank high in credibility.

Little, T., and R. A. Hill. 1993. CRP having an impact. *Iowa Conservationist* Sept./Oct.:4-9.

Description of agricultural and settlement impacts on wildlife habitats in Iowa. General description of CRP benefits to wildlife. Authors indicated that converting as little as 4% of county from rowcrops to CRP increased pheasant numbers seen on survey routes. Higher numbers of pheasants attributed to greater overwinter survival due to CRP. They reported > 15 nests of nongame birds per 40 acres of CRP compared to less than one nest in same area of rowcrops. Nest success of birds in CRP was 33% compared to 20% in hayfields. Waterfowl nest success in CRP as good or better than that observed in wildlife management areas.

Liverman, M., and T. Hemker. 1995. Agriculture/wildlife relationships in the western region. *Transactions of the North American Wildlife and Natural Resources Conference* 60:320-326.

Authors emphasized the importance of agricultural habitats for fish and wildlife in western region. Habitat needs and Farm Bill recommendations were provided for rangelands, croplands, aquatic habitats, species of special status, and woodlands.

Lokemoen, J. T., and J. A. Beiser. 1979. Bird use and nesting in conventional, minimum-tillage, and organic cropland. *Journal of Wildlife Management* 43:644-655.

Seasonal use by birds and nesting was evaluated in fallow, sunflower, and wheat fields among conventional farms, minimum tillage farms, reduced tillage, and organic farms (no synthetic pesticides). Spring bird densities were highest in minimum-tillage, fallow fields that provided food and cover. No differences in bird densities among crops of various field types in fall or winter, but mean densities in summer were highest in fallow fields. Fallow fields also had greater mean number of nesting species. Elevated densities of birds and nests in fallow fields were attributed to increased amounts of plant litter cover. Mean number of nesting species and nest densities were higher in minimum tillage and organic fields. Overall hatching success was low for waterfowl and shorebirds; nest success was also low for passerines. Nest losses were due to predation and farming activities. Hatch success was higher in minimum tillage fields for passerines and wheat fields for shorebirds. Nest densities in CRP were six-times greater than that found in minimum tillage stubble and organic fallow and 11-times larger than densities in other field types and crops.

Luttschwager, K. A. 1991. Effects of two haying provisions on duck nesting in Conservation Reserve Program (CRP) fields in South Dakota. M.S. thesis. South Dakota State University, Brookings. 51 pp.

Evaluation of the effects of two emergency haying provisions on duck nesting in CRP fields in South Dakota in 1988 and 1989. Nest densities in idle (nonhayed) strips and nonhayed fields were significantly greater than in hayed strips. Nest densities in idle and hayed blocks were similar. Nest success was lowest in idle strips that apparently attracted predators as well as ducks. Author recommended leaving a minimum of 25% of CRP fields in undisturbed block rather than in strips.

Luttschwager, K. A., and K. F. Higgins. 1991. Some sociological and ecological effects of the Conservation Reserve Program in the northern Great Plains. Pages 58-62 in L. A. Joyce, J. E. Mitchell and M. D. Skold, editors. *The Conservation Reserve - yesterday, today, and tomorrow*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-203. 64 pp.

General treatment of benefits of CRP for improved air and water quality, provision of wildlife habitat, and reduction of soil erosion. Authors concluded that economic benefits were equivocal, raising net farm income, but reducing local economies. See also Luttschwager et al. (1994) regarding effects of emergency haying on nesting birds.

Luttschwager, K. A., and K. F. Higgins. 1992. Nongame bird, game bird, and deer use of Conservation Reserve Program fields in eastern South Dakota. *Proceedings of the South Dakota Academy of Science* 71:31-36.

Luttschwager, K. A., K. F. Higgins, and J. A. Jenks. 1994. Effects of emergency haying on duck nesting in Conservation Reserve Program fields, South Dakota. *Wildlife Society Bulletin* 22:403-408.

Study of duck nest densities and nest success among hayed and idled strips, blocks of planted grass, and idled CRP fields. Study was conducted in 1989 and 1990 in fields established in 1986 or 1987. Nest density in idle strips, blocks, and fields was 4-times greater than densities in hayed strips or blocks. Nest density in idled strips and fields higher than hayed strips, but success was reduced in [narrow] idled strips compared to [wide] hayed strips and idled fields. In 1990, hayed blocks had higher density of successful nests than strip cover. Authors concluded that annual haying was always undesirable for nesting waterfowl, but periodic mowing may be beneficial if performed in blocks (vs. strips) after July 20.

Lysne, L. A. 1991. Small mammal demographics in North Dakota Conservation Reserve Program plantings. M.S. thesis. University of North Dakota, Grand Forks. 48 pp.

Study conducted in North Dakota in summers of 1989 and 1990 examined small mammal demographics and population dynamics in four age classes of CRP plantings. Small mammal diversity on CRP tracts less than four years old was low. Eight species were detected with deer mice comprising 92% of all small mammals recorded. Density of deer mice changed seasonally and differed between years. Home range size and abundance similar for males and females. Author speculated that small mammal diversity and density of meadow voles would increase as CRP fields matured and litter accumulated. Author discussed potential effects of disturbances on small mammal community in CRP fields.

Maddox, J. D., and E. K. Bollinger. 2000. Male Dickcissels feed nestlings in east-central Illinois. *Wilson Bulletin* 112:153-155.

Report of males feeding nestlings in CRP fields in east-central Illinois. Annual variation in male provisioning attributed to differences in food abundance between years.

Major, R. E., F. J. Christie, G. Gowing, and T. J. Ivison. 1999. Elevated rates of predation on artificial nests in linear strips of habitat. *Journal of Field Ornithology* 70:351-364.

Comparison of nest predation rates and identity of nest predators between linear remnants and large remnants of woodland in Wheatbelt of Australia. Incidence of predation on artificial nests and number of predator species was greater in linear than in large remnants. Authors conclude that linear strips have limited value as breeding habitat.

Mankin, P. C. 1993. Agricultural land use and the eastern cottontail in Illinois. Ph.D. dissertation. University of Illinois, Urbana-Champaign. 94 pp.

Mankin, P. C., and R. E. Warner. 1999. Responses of eastern cottontails to intensive rowcrop farming. *Journal of Mammalogy* 80:940-949.

Study evaluated responses of eastern cottontails to intensive rowcrop farming in Illinois. Home ranges of cottontails averaged 2.3-times larger during growing season than in nongrowing season. During nongrowing season, homesteads were major component of home ranges. Homesteads made up < 2% of the study area but comprised 23% of home ranges and 40% of rabbit locations. Declines in rabbit numbers have been most pronounced in

intensively farmed regions where rowcrop agriculture has replaced pasture, other early successional perennial vegetation, forage crops, and small grains. Loss of cottontail habitat in Midwest also attributed to greater use of herbicides and intensive fall tillage.

Margheim, G. A. 1994. Soil erosion and sediment control. Pages 15-18 in *When Conservation Reserve Program contracts expire: The policy options*. Soil and Water Conservation Society, Ankeny, Iowa.

Annual reduction in soil erosion attributed to the CRP was estimated at almost 700 million tons. If savings associated with lower commodity price support payments are considered with the productivity gains and environmental benefits, the total benefits of CRP exceed the program's costs. The author recommended targeting only the most highly erodible lands for CRP. This could provide an additional five to 10 percent reduction in soil erosion.

McCoy, T. D. 1996. Avian abundance, composition, and reproductive success on Conservation Reserve Program fields in northern Missouri. M.S. thesis. University of Missouri, Columbia.

Grassland bird species richness was higher on structurally diverse CP1 fields than on CP2 fields. Vegetation in CP2 fields was tall, dense monotypic stands of warm-season grass (switchgrass). In areas where grass monocultures exist, disturbances to decrease the height and density of vegetation and increase plant diversity may be beneficial for grassland birds. Provisions for periodic haying and grazing may enhance habitat value.

McCoy, T. D., M. R. Ryan, E. W. Kurzejeski, and L. W. Burger. 1999. Conservation Reserve Program: Source or sink habitat for grassland birds in Missouri. *Journal of Wildlife Management* 63:530-538.

Study estimated fecundity of seven grassland bird species nesting in CRP fields in northern Missouri. They compared their results with estimates of fecundity necessary to maintain stable populations. Results varied by species and year. Authors concluded that CRP contributed to conservation of grasshopper sparrows, field sparrows, and eastern meadowlarks; they found little evidence that CRP was beneficial for dickcissels or red-winged blackbirds.

McKean, J. R., and R. L. Johnson. 1993. Can increased migratory bird hunting offset negative economic impacts of the CRP in northeast Colorado? *Colorado State University Experiment Bulletin*. Fort Collins.

McKean, J. R., E. Ekstrand, and R. L. Johnson. 1994. Recreational fishing offsets to the negative economic impacts of the CRP in Wisconsin. *Colorado State University Experiment Bulletin*. Fort Collins.

McKinnon, D. T., and D. C. Duncan. 1999. Effectiveness of dense nesting cover for increasing duck production in Saskatchewan. *Journal of Wildlife Management* 63:382-389.

Comparison of nesting success and nest density of mallards, gadwalls, northern shovelers, and blue-winged teal in unmanaged plots (UM) and plots with dense nesting cover (DNC) in Saskatchewan prairie-parkland. Nesting success for all species combined was greater in DNC than in UM, but varied by species, treatment, and plots. Conversion of cropland to pasture was recommended as cost-effective strategy for increasing duck numbers.

Millenbah, K. F. 1993. The effects of different age classes of fields enrolled in the Conservation Reserve Program in Michigan on avian diversity, density, and productivity. MS thesis. Michigan State University, East Lansing.

Avian communities and vegetative characteristics were examined in six age-class fields (one to six growing seasons) in central Michigan to determine relations between field age and characteristics of avian communities. Results suggested a relationship between age of CRP fields and avian abundance, diversity, and productivity. Younger CRP fields that were characterized by forbs and bare ground supported greater densities and diversities of birds than older fields. Older fields with greater litter cover and grass cover supported the greatest productivity. Few significant differences were found among field age-classes but mean insect diversities and biomass generally decreased as CRP fields aged. Seventy percent of surveyed landowners considered improvement of wildlife habitat in their decision to enroll into CRP. Author concluded that grassland birds may require a diversity of age classes of CRP fields in agricultural landscapes to meet habitat requirements. She recommended controlled disturbance in years four through six.

Millenbah, K. F., S. R. Winterstein, H. Campa III, L. T. Furrow, and R. B. Minnus. 1996. Effects of Conservation Reserve Program field age on avian relative abundance, diversity, and productivity. *Wilson Bulletin* 108:760-770.

Study conducted in Michigan in 1992 examined effects of age of CRP fields on avian relative abundance, diversity, and productivity. CRP fields dominated by introduced grasses and legumes had greatest avian diversity and abundance at one to two years old; avian productivity was greatest in older fields (three to five/six years of age) with several grass species and deep litter. Authors recommended that CRP fields be periodically disturbed to provide a variety of successional stages.

Miller, E. J. 1989. Wildlife management on Virginia Conservation Reserve Program land: The farmers' view. M.S. thesis. Virginia Polytechnic Institute and State University, Blacksburg. 91 pp.

Seventy-two percent of respondents indicated that they wanted to improve wildlife habitat on retired land. Most respondents indicated that they had not been informed about improving habitat on CRP land. USDA personnel were primary source of habitat information for program participants. Only 5% of land was planted to permanent wildlife habitat. Mowing of entire CRP acreage was primary means of weed control. Leasing of CRP land to hunters was uncommon. Results indicated a high level of interest in wildlife and need for getting more detailed information to landowners from USDA and wildlife agencies.

Miller, E. J., and P. T. Bromley. 1989. Wildlife management on Conservation Reserve Program land: The farmers' view. *Transactions of the North American Wildlife and Natural Resources Conference* 54:377-381.

Survey of CRP participants in Iowa and Virginia indicated that most were interested in improving CRP fields for wildlife. Lack of specific information and education about how to improve lands for wildlife appeared to be an important limitation. Objection to regulations and "red tape" may have further constrained adoption of habitat improvement programs. Improvements in wildlife habitat on CRP lands will require aggressive outreach by wildlife agency staff (rather than USDA county staff) who can furnish precise information for improvement in habitat for wildlife.

Miller, E. J., and P. T. Bromley. 1989. Wildlife management on Conservation Reserve Program land: The farmers' view. *Journal of Soil and Water Conservation* 44:438-440.

Results from a survey of Iowa and Virginia farmers regarding their interest in improving wildlife habitat, adequacy of available information on wildlife habitat options, current management of

retired land, and financial incentives required to implement a wildlife plan. Constraints to implementing wildlife measures included lack of information, negative attitudes toward hunters, high costs of wildlife covers, and physical limitations of CRP participants. Authors recommended aggressive distribution of information and education efforts by wildlife and extension agencies.

Miller, M. S., D. J. Buford, and R. S. Lutz. 1992. Habitat use, productivity, and survival of Rio Grande wild turkey hens in southwestern Kansas. Page 27 in 1991 Noxious brush and weed control: Range and wildlife management. Texas Tech University, Lubbock.

Miller, M. W. 2000. Modeling annual mallard production in the prairie-parkland region. *Journal of Wildlife Management* 64:561-575.

Evaluation of the effect of precipitation, cold spring temperatures, wetland abundance, and upland breeding habitat on mallard production in the prairie-parkland region of the United States and Canada. May-June pond numbers and size of breeding population best predicted mallard production at continental scale. Variables that best modeled production at stratum scale differed by region.

Mills, R. C. 1993. CRP grassland and wildlife management. U.S. Department of Agriculture, Soil Conservation Service. *Missouri Bulletin No. MO300-3-1*. 9 pp.

Minnesota Extension Service. 1993. The CRP in the Midwest: What should we do next? University of Minnesota, St. Paul. 16 pp.

Miranowski, J. A., and R. L. Bender. 1982. Impact of erosion control policies on wildlife habitat on private lands. *Journal of Soil and Water Conservation* 37: 288-291.

Analysis of relation between upland wildlife habitat quality and erosion control policies for protection of soil productivity and improvement of water quality. Authors concluded that (1) policies designed to reduce soil erosion tended to improve upland habitat quality and water quality; (2) some policies were more effective than others at improving habitat; and (3) policies that encouraged changes in land use had greater effect on habitat quality than did changes in tillage systems.

Moulton, R. J. 1994. Sorting through cost-share assistance programs. *Tree Farmer*. November/December 1994.

Moulton, R. J., B. Baldwin, and J. Snellgrove. 1991. Impacts of Conservation Reserve Program tree planting on biological diversity. *Southern Forest Economist*, Feb. 20-22, 1991. Washington, D.C.

Sample of CRP plantations in Southeast showed that most were comparatively small and over 70% were freestanding (i.e., not adjoined by existing pine stands) and none were encompassed within pine stands. Over 2.2 million acres of trees have been planted under CRP, mostly in southeastern states. Trees represented > 90% of CRP in Florida and Georgia, 79% in South Carolina, and > 50% in Alabama, Arkansas, Louisiana, Mississippi, and North Carolina. Ninety-seven percent of tree plantings were softwoods (loblolly and slash pine). CRP pine replaced cropland in 80% of cases.

National Audubon Society. 1994. Investing in wildlife, multiple benefits for agriculture and the American people. Washington, D.C. 27 pp.

National Audubon Society. 1995. Investing in wildlife, multiple benefits for agriculture and the American people. Washington, D.C. 16 pp.

This brochure was prepared by the National Audubon Society to describe the benefits of certain agricultural practices to wildlife in support of the development of the 1996 Farm Bill. The wildlife benefits of the first 10-year CRP contracts were described. Other USDA programs described include: Water Bank, Water Quality Incentives Program, Agriculture Conservation Program, Wetlands Reserve Program, and debt restructure through the Farmers Home Administration. The article concludes with the Society's recommendations for changes in the 1995 Farm Bill.

National Research Council. 1982. Impacts of emerging agricultural trends on fish and wildlife habitat. National Academy Press. 244 pp.

Newtow, J. A., and J. S. Beck. 1993. Conservation Reserve Program fish and wildlife benefits. State of Oregon report to local Soil and Water Conservation Districts. Oregon Department of Fish and Wildlife, Salem.

Niemuth, N. D. 2000. Land use and vegetation associated with greater prairie-chicken leks in an agricultural landscape. *Journal of Wildlife Management* 64:278-286.

Comparison of land use around greater prairie chicken leks and random points in a central Wisconsin agricultural landscape. Areas around leks had greater proportions of grasslands, wetlands, and

shrubs, and lower proportions of forests, rowcrops, and hayfields than areas around random points. Differences between leks and random points and correlates of number of males varied with scale of sampling.

Nowak, P. J., M. Schnepf, and R. Barnes. 1990. A national survey of farm owners and operators who have enrolled land in the Conservation Reserve. Soil and Water Conservation Society. Ankeny, Iowa.

O'Connell, M. A., and R. F. Noss. 1992. Private land management for biodiversity conservation. *Environmental Management* 16:435-450.

For the purpose of conservation, ecosystem diversity must be defined on basis of geographically recognizable units representing commonly associated flora and fauna. Species profiting from habitat diversification are generally least in need of conservation efforts (e.g., species associated with diversification in cover types). Managers have customarily enhanced local species diversity by maintaining numerous edges between habitat types; however, this practice usually is detrimental for endemic species. Maintenance of diversity from regional and global perspective actually permits more flexibility in land use options than a strategy that considers sites in isolation. For example, loss of a species from a specific site may not have detrimental effects for biodiversity if the species is regionally or globally abundant. Regional biodiversity management does not preclude habitat manipulation to favor certain species; however, standards for private land management consistent with goal of conserving biodiversity are not simple to delineate. Paper provided specific steps and guidelines for identification of biodiversity priorities on private lands.

O'Connor, R. J., and M. Shrubbs. 1986. Farming and birds. Cambridge University Press, Great Britain. 290 pp.

Ogg, C. W., M. P. Aillery, and M. O. Ribaud. 1989. Implementing the Conservation Reserve Program: Analysis of environmental options. U.S. Department of Agriculture, Forest Service, Economic Research Service, Agriculture Economic Report 618. Washington, D.C. 26 pp.

Osborn, C. T., F. Llacuna, and M. Linsenbigler. 1992. The Conservation Reserve Program, enrollment statistics for sign-up periods 1-11 and fiscal years 1990-92. U.S. Department of Agriculture, Economic Research Service, Statistical Bulletin Number 843. Washington, D.C. 86 pp.

Osborn, C. T., F. Llacuna, and M. Linsenbigler. 1995. The Conservation Reserve Program, enrollment statistics for sign-up periods 1-12 and fiscal years 1990-93. Department of Agriculture Economic Research Service, Statistical Bulletin Number 843. Washington, D.C. 102 pp.

Report presented tables for all CRP cropland enrolled in sign-ups 1-12 and CRP cropland newly retired between 1986 and 1993.

Osborn, C. T., M. Schempf, and R. Keim. 1995. The future use of Conservation Reserve Program acres: A national survey of farm owners and operators. Soil and Water Conservation Society, Ankeny, Iowa. 47 pp.

Owens, R. A., and M. T. Myres. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. *Canadian Journal of Zoology* 51:697-713.

Disturbance of fescue grasslands by haying or grazing reduced or eliminated Baird's sparrow and Sprague's pipit, but permitted ingress of horned lark and chestnut-collared longspur. Removal of native grasslands by plowing and cultivation for cereal crops eliminated all passerine species except the horned lark. Vegetation physiognomy probably influenced the distribution of grassland passerine species. Prairie passerines that evolved to exploit original grassland environments were forced use of various habitats created by agriculture. Species that required dense grass were largely eliminated by heavy grazing. Varying grazing intensities will produce changes in vegetative structure and composition of grassland bird community. Under light to moderate grazing, the full range of prairie passerines may occur. Under heavier than normal grazing, species that favor shortgrass will predominate. Some species will be present under any condition (meadowlarks). Native passerines are adapted to habitats that were grazed by ungulates and subject to periodic fires. Therefore, areas managed to preserve grasslands and native avifaunas should allow these factors to operate to create similar conditions.

Pajak, P. 1991. Fisheries implications of the 1990 Farm Bill. *Fisheries* 16:4.

Pajak, P., and J. Bauman. 1992. Fisheries resources: Opportunities for enhancement through the Conservation Title. The social, economic, and environmental consequences of the conservation components of the Food Security Act of 1985. Soil and Water Conservation Society Symposium, March 1-2, 1989. Columbus, Ohio.

Patterson, M., and L. B. Best. 1993. Avian abundance and productivity on Conservation Reserve Program lands in central Iowa (abstract only). *Proceedings of the Midwest Fish and Wildlife Conference* 55:171.

Patterson, M. P., and L. B. Best. 1996. Bird abundance and nesting success in Iowa CRP fields: The importance of vegetation structure and composition. *American Midland Naturalist* 135:153-167.

Although many bird species frequented rowcrop fields, abundance was relatively low and few species nested there. Because of predation, parasitism, and farming activities, bird reproduction in rowcrops may be below levels needed to sustain populations. CRP likely has contributed to an increase in the abundance of many bird species in central Iowa, because it replaced rowcrop with permanent grass cover. CRP fields were better nesting habitat for grassland birds than roadsides, grassed waterways, and other covers associated with Iowa agriculture. Differences in nesting success between habitats were attributed to diverse vegetation structure and composition, large block nature, and reduced agricultural activity in CRP. Authors recommended (1) selection of CRP plantings that provide diverse structure and composition favored by grassland birds; (2) deferral of mowing and spraying of CRP fields for weed control until after July; and (3) maintenance of whole field enrollments. They indicated that the effects of disturbances (disking, burning, grazing, and interseeding) needed further evaluation.

Pearks, A. J. 1995. The effects of habitat manipulation on vegetation characteristics and avian communities on Conservation Reserve Program fields in Gratiot County, Michigan. M.S. thesis. Michigan State University, East Lansing.

Pimental, D. U. Stachow, D. A. Takacs, H. W. Brubaker, A. R. Dumas, J. J. Meaney, J. A. S. O'Neil, D. E. Onsi, and D. B. Corzilius. 1992. Conserving biological diversity in agricultural/forestry systems. *BioScience* 42:354-362.

Authors argued that because agriculture, forestry, and human settlements occupy up to 95% of terrestrial environment, a large portion of world's biodiversity coexists within these ecosystems. Paper provided general treatment of concept of biological diversity (e.g., definitions, abundance, biomass, and diversity of organisms in relation to their size and phylogeny) and discussed implications of specific agricultural practices for biological diversity. Authors maintained that biological diversity in agricultural/forestry systems can best be conserved by (1) sustaining abundant biomass/energy and plant and habitat diversity; (2) conserving soil, water, and biomass resources; and (3) reducing the use of pesticides and similar toxic chemicals.

Price, M. 1991. Family farming in Minnesota. *Soil and Water Conservation News* 12:12-13.

The author described CRP activities in Minnesota. He also noted the U.S. Fish and Wildlife Service role in wetland restoration on CRP lands. Landowner quotes and photographs were provided to illustrate wildlife, soil, and water quality benefits of CRP.

Reichelderfer, K. 1990. Environmental protection and agricultural support: Are trade-offs necessary? Pages 201-230 in K. Allen, editor. *Agricultural policies in a new decade*. Resources for the Future and National Planning Association. Washington, D.C.

Author suggested that traditional means of supporting farm income tended to exacerbate environmental problems. Under current programs, agricultural and environmental protection reflect conflicting societal preferences. Public reaction to environmental problems suggests that nonfarm population believes that their right to a clean, safe, and healthy environment may be infringed upon by farming activity. Long-term environmental goals of American public conflict with the short-run profit objectives of individual farmers. Adoption of new technologies requires capital investment, increased operating costs, or some forfeiture of yield, any of which can reduce farm income in the short run. Efforts, therefore, must focus on increasing the cost-effectiveness of environmentally friendly technologies and higher levels of funding to meet policy objectives. Farm Bill has provided some consistency between environmental and agricultural policy objectives, but it could be improved.

Renner, R. W., R. E. Reynolds, and B. D. J. Batt. 1995. The impact of haying Conservation Reserve Program lands on productivity of ducks nesting in the Prairie Pothole Region of North and South Dakota. *Transactions of the North American Wildlife and Natural Resources Conference* 60:221-229.

Comparison of nest success and duck production in hayed versus nonhayed portions of CRP fields. Production was higher on nonhayed portions. Authors suggested that changes in litter depth and vegetation structure caused by haying might adversely impact nesting through entire year following haying. They recommended haying no more than once every five years to maintain vegetation quality and habitat diversity.

Renner, R. W., R. E. Reynolds, and B. D. J. Batt. 1995. The impact of haying Conservation Reserve Program lands on productivity of ducks nesting in the Prairie Pothole Region of North and South Dakota. Unpublished Report. 25 pp.

In 1994, the authors conducted a one-year study of the impact of emergency haying of CRP fields to duck production in the Prairie Pothole Region of North and South Dakota. In 1993, 50 North Dakota and 47 South Dakota counties were opened to emergency haying from mid-August to late September. This investigation showed mean production of hatchlings was higher in undisturbed CRP fields than in hayed CRP fields. The mean daily survival rate of nests was not significantly different. Nest densities of all species combined were significantly higher in undisturbed fields. The authors recommended haying CRP no more than once every five years to maintain vegetation quality and habitat diversity.

Reynolds, R. 1992. Evaluation of the effect of CRP on duck recruitment in the Prairie Pothole Joint Venture Area of FWS, Regions 6. U.S. Fish and Wildlife Service Progress Report. Bismarck, North Dakota. 6 pp.

Report on results of 1992 pilot effort to evaluate waterfowl production in Montana, North Dakota, and South Dakota. Nest success was estimated to be about two- to three-times higher in CRP grasslands than in Waterfowl Production Areas.

Reynolds, R. 1994. Evaluation of the effect of CRP on duck recruitment in the Prairie Pothole Joint Venture Area of FWS, Region 6. 1994 Progress Report. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 4 pp.

The objective of this four-year study was to evaluate the effect of the CRP on the recruitment of ducks in the Prairie Pothole Joint Venture Area of Montana, North Dakota, and South Dakota. This report summarized the first three years of findings. The study area covers approximately 2.9 million acres of CRP lands and in 1994, with excellent wetland conditions, an estimated 37 nests per 100 CRP acres were initiated over the entire study area. Nest success was estimated to be 18 to 30 percent, which was higher than considered necessary to maintain a stable duck population. Authors speculated that benefits of CRP extended beyond nesting cover and included increased brood survival. It was noted that large portions of CRP in the Dakotas were opened for emergency haying in 1993. Nest densities in the following year were lower on those fields that had been hayed in the previous summer. The author concluded this activity would have greater impact on early nesting species such as mallard and northern pintail.

Reynolds, R. E., D. R. Cohan, and M. A. Johnson. 1996. Using landscape information approaches to increase duck recruitment in the Prairie Pothole Regions. *Transactions of the North American Wildlife and Natural Resources Conference* 61:86-93.

Authors described procedure to prioritize areas for nesting duck management based on models developed from digital wetland data, data on duck pair/wetland relationships, and breeding duck home range characteristics. Procedure was applied to two North Dakota counties; the resulting map displayed the area as four priority levels based on their potential for breeding ducks. Utility of map was demonstrated by selecting example areas and prescribing specific treatments based on other landscape characteristics.

Reynolds, R. E., D. R. Cohan, and A. Kruse. 1994. Which cropland to retire: A waterfowl perspective. Pages 110-111 in *When Conservation Reserve Program contracts expire: The policy options*. Soil and Water Conservation Society, Ankeny, Iowa.

Authors used mallard population model to assess the impact of CRP acreage reductions on sample population of waterfowl in the Prairie Pothole Region of North Dakota.

Reynolds, R. E., T. L. Shaffer, R. W. Renner, W. E. Newton, and B. D. J. Batt. In review. Impact of the Conservation Reserve Program on duck recruitment in the U.S. Prairie Pothole Region. *Journal of Wildlife Management*. In review.

Authors estimated contribution of CRP to waterfowl recruitment in U.S. Prairie Pothole Region during 1992-1997. Survival of duck nests was positively related to proportion of perennial cover in study plots for four or five duck species and generally was higher during CRP period than during pre-CRP period in all habitat types. Compared to a simulated landscape in which CRP was replaced by cropland, estimated nest success was 50% higher and recruitment rates were 31% higher for five species combined in 1992-1997. It was estimated that CRP contributed an additional 10.5 million waterfowl to fall flight during 1992-1997.

Reynolds, R. E., T. L. Shaffer, J. R. Sauer, and B. G. Peterjohn. 1994. Conservation Reserve Program: Benefit for grassland birds in the northern Plains. *Transactions of the North American Wildlife and Natural Resources Conference* 59:328-336.

This study compared daily survival rates of duck nests in CRP fields to those found in other planted cover, and compared population trends for nonwaterfowl populations in the Prairie Pothole Region of North and South Dakota in 1992 and 1993. The authors concluded that CRP provided benefits for some grassland nesting

birds. Nest success for mallard, gadwall, and blue-winged teal in CRP cover was two to nine percent higher than the threshold value needed for population maintenance. Nest success of ducks was similar in CRP sites and other sites with planted cover. Authors reported that some, but not all, grassland nesting birds had population increases since the establishment of the CRP. Factors other than breeding habitat availability may be influencing species that have not shown population increases.

Ribaudo, M. O. 1989. Water quality benefits from the Conservation Reserve Program. U.S. Economic Research Service, Agricultural Economic Report 606. Washington, D.C.

Ribic, C. A., R. E. Warner, and P. C. Mankin. 1998. Changes in upland wildlife habitat on farmland in Illinois 1920-1987. *Environmental Management* 22:303-313.

Authors developed an index to evaluate changes in agricultural ecosystems as they affected wildlife habitat. Indices at the county level had potential to be used in a multi-scale analysis to investigate the impact of policy changes on large-scale areas of the Midwest and to develop regional perspectives of the impacts of agriculture on upland wildlife and habitats.

Rietveld, W. J. 1993. When CRP contracts expire: Alternative strategies to encourage environmentally acceptable land use. Pages 89-96 in *Proceedings of the Great Plains Agricultural Council. Annual meeting*, June 2-4. Rapid City, South Dakota.

Riddle, M., M. D. Skold, and W. L. Trock. 1994. The future of the Conservation Reserve Program in Colorado. Colorado State University, Department of Agricultural and Resource Economics, Technical Report TR94-5. 41 pp.

Survey of CRP participants in Colorado to ascertain their expectations of CRP. Economic factors were the most important reason for program participation. Soil conservation also was an important consideration. If program expired, respondents indicated that about 38% of CRP land would be returned to production and a similar amount would remain in grass. Infrastructure to accommodate livestock generally not available on CRP grasslands. New fences and development of water resources would be needed to convert CRP grassland to grazing.

Riley, S. P. 1995. CRP: Icon of a new age. *Transactions of the North American Wildlife and Natural Resources Conference* 60:327-329.

Personal reflection of Farm Bill benefits for wildlife.

Riley, T. Z. 1992. Ring-necked pheasants and food plot size. *Prairie Naturalist* 24:185-189.

Study examined the relation of food plot size to winter use by pheasants in north-central Iowa in 1986 and 1988. Relationship differed between years and sexes, but was strongest in the coldest winter with greatest snowfall. Author recommended food plots  $\geq 4$  ha in size.

Riley, T. Z. 1993. Effects of CRP on ring-necked pheasants in Iowa (1985-91). *Proceedings of the Midwest Fish and Wildlife Conference* 55:172 (abstract only).

Riley, T. Z. 1995. Association of Conservation Reserve Program with ring-necked pheasant survey counts in Iowa. *Wildlife Society Bulletin* 23:386-390.

Pheasant numbers in Iowa increased 30% during first five years of CRP compared to a similar period before the program. Numbers increased 34% in counties with  $> 70\%$  of cropland and 26% in counties with 50-70% cropland. Increases not detected in counties with  $< 50\%$  in cropland. Pheasant numbers positively related to CRP but also influenced by percent cropland and cumulative snowfall. Positive association between pheasant survey counts and CRP land enrollment may have resulted from an increase in nesting and winter cover. Addition of idle grass-forb fields provided by program might have improved survival of females and enhanced reproductive success by increasing amount and dispersion of roosting and nesting cover.

Risley, D. L., D. P. Scott, and A. H. Berner. 1995. Midwest wildlife needs assessment for the 1995 Farm Bill - a need to focus efforts. *Transactions of the North American Wildlife and Natural Resources Conference* 60:281-287.

Authors provided history of land retirement programs, landscape changes, and decline in wildlife populations in midwestern states. Habitat goals for grassland-nesting, wetland-dependent, forest, and riparian/aquatic wildlife were provided. Farm Bill strategy was outlined.

Risley, D. L. et al. 1995. 1995 Farm Bill: Wildlife options in agricultural policy. *Wildlife Society Technical Review* 95-1. 24 pp.

This publication described the 1985 and 1990 Farm Bills and all the conservation programs and provisions including CRP, Swampbuster, Sodbuster, Conservation Compliance, Wetlands Reserve Program, Forest Stewardship Program, and Farmers Home Administration programs. It provided a summary of wildlife research conducted on CRP lands. Current implementation practices were described. The Wildlife Society's recommendations for the 1995 Farm Bill were provided.

Robinson, A. Y. 1991. Agriculture and wildlife in 2020. Pages 67-76 in T. J. Peterle, editor. *2020 Vision: Meeting the fish and wildlife conservation challenges of the twenty-first century*. Midwest Fish and Wildlife Conference, December 3, 1991. Des Moines, Iowa.

Robinson, A. Y. 1988. Implementation of conservation compliance: Implications for soil, water, and wildlife. *Transactions of the North American Wildlife and Natural Resources Conference* 53:210-221.

Early review of legal, administrative, social, economic, and environmental aspects of conservation compliance provisions of 1985 Food Security Act.

Robinson, S. K., J. A. Grzybowski, S. I. Rothstein, M. C. Brittingham, L. J. Petit, and F. R. Thompson. 1993. Management implications of cowbird parasitism on Neotropical migrant songbirds. Pages 93-102 in D. M. Finch and P. W. Stangle, editors. *Status and management of Neotropical migratory birds*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-229. 422 pp.

Human activities have contributed to increases in cowbird populations that now potentially threaten populations of many Neotropical migrant songbirds. Best preventative measure is to manage large areas on a landscape level. Bigger tracts are preferable to smaller ones and compact shapes (square) are better than complex shapes with high ratios of edge to interior. Acquisition should focus on inholdings to minimize fragmentation. Woody fencerows, snags, and corridors within and adjacent to prairie should be removed.

Robel, R. J., J. P. Hughes, S. D. Hull, K. E. Kemp, and D. S. Klute. 1998. Spring burning: Resulting avian abundance and nesting in Kansas CRP. *Journal of Range Management* 51:132-138.

Study evaluated the effects of spring burns (1992-1995) on vegetation structure and avian populations in southeastern Kansas CRP fields planted to native grasses. Spring burning reduced nest numbers in the summer of management action but did not reduce the number of nests found in those fields in following summers. Annual burning was considered to be too frequent to maximize avian habitat quality. Less frequent application of fire as a management tool was recommended.

Robel, R. J., and K. E. Kemp. 1997. Winter mortality of northern bobwhites: Effects of food plots and weather. *Southwestern Naturalist* 42:59-67.

Winter mortality rate was estimated for northern bobwhite quail in Kansas. Estimated mortality rates for bobwhites within 600 m of food plots ranged from 24-46% vs. 20-82% for bobwhites > 900 m from food plots. Number of days with > 10 cm snow cover and duration of < 5°C January temperatures were significantly correlated with and best predictors of mortality.

Robinson, R. A., L. L. Atkins, C. R. Kirby, P. A. Dommel, F. J. Schaefer Jr., and J. D. Hall. 1992. Conservation Reserve Program: Cost effectiveness is uncertain. Report to the Chairman, Subcommittee on Agriculture, Rural Development, Food and Drug Administration, and Related Agencies, Committee on Appropriations, House of Representatives. U.S. General Accounting Office. GAO/RCED-93-132. 14 pp.

Rodiek, J., and G. DelGiudice. 1994. Wildlife habitat conservation: Its relationship to biological diversity and landscape sustainability: A national symposium. *Landscape Urban Planning* 28:1-3.

Rodenhouse, N. L., and L. B. Best. 1983. Breeding ecology of vesper sparrows in corn and soybean fields. *American Midland Naturalist* 110:265-275.

Nesting success in corn and soybean fields was low. Nest losses were due primarily to agricultural operations and predation. Nest predation was higher near uncultivated edges because of increased predator activity. On cultivated land, nest predators use strip-cover as travel lanes, thus higher predation in or near these habitats should be expected. Breeding success would be greater if the number of tillage operations was reduced and crop residue was retained on the fields.

Rodenhouse, N. L., L. B. Best, R. J. O'Connor, and E. K. Bollinger. 1993. Effects of temperate agriculture on Neotropical migrant landbirds. Pages 280-295 in D. M. Finch and P. W. Stangle, editors. Status and management of Neotropical migratory birds. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-229. 422 pp.

Ecology of Neotropical migrant landbirds was reviewed for the purpose of developing management recommendations. Migrants constituted about 71% of bird species using farmland and 86% of bird species nesting there. Migrants' use of farmland was greatest in uncultivated edges with trees and shrubs; intermediate in uncultivated, grassed areas; and lowest in rowcrops. Increasing agricultural mechanization and chemical use have probably lowered the breeding productivity of migrants. Homogeneous, larger farms specializing in few commodities have created ecosystems that often lack suitable interspersed required habitat resources. Practices that promote greater productivity include reduced tillage, inorganic fertilizer application, and use of integrated pest management.

Most migrants using temperate farmland were grassland or edge species. Agriculture was implicated in the decline of all nine Neotropical migrants currently listed (or candidate species) as threatened or endangered. How agriculture has contributed to this is unclear, but farmland structure and types of crops grown are probably major factors. The percentage of farmland in hay or pasture or in uncultivated semi-natural habitat was negatively correlated with area of intensively cultivated rowcrops.

Diversity and abundance of migrants were greater in wider strips of uncultivated edge vegetation. Uncultivated wooded areas included wooded fencerows or the edges of fields bordering woodland; grassed edge included some fencerows, waterways, terrace berms, road edges, and most land in the CRP. Breeding productivity of migrants in farmland was often below the threshold level needed for population maintenance. Percentage of county area in the CRP was positively associated with the abundance of 19 migrant species, 12 of which were grassland species.

Many migrants are wholly or partly insectivorous. Abundance of litter-dwelling arthropods was greater in fields where plant litter on soil surface was relatively dense. Herbicides and insecticides reduced food availability for birds. Areas in permanent cover, even if only grasses or no-till cropland, generally supported higher arthropod abundance than conventionally tilled fields. Arthropod abundance was greater near permanent vegetated field edges and greater in fields surrounded by complex habitats. Weed seeds were more abundant near uncultivated areas because of seed dispersal from uncultivated areas and because permanent vegetation concentrated wind-dispersed arthropods and seeds. Homogenization of farmland lowers diversity and abundances of plants, seeds, and arthropods within field and the landscape.

Presence of sheltering vegetation may be needed for some migrants, particularly edge species. Farmland complexity has declined in most agricultural regions because of increased use of large equipment, larger field size, crop specialization, and increased average size of farms. Absence of safe nesting sites may be limiting reproduction and survival of migrants in cropland. Agricultural land uses increased concentrations of nesting birds and predators. Authors also discussed the future of agriculture, provided management recommendations, and identified research needs.

Rodgers, R. D., and J. B. Wooley. 1983. Conservation tillage impacts on wildlife. *Journal of Soil and Water Conservation* 38:212-213.

Paper outlined potential benefits of conservation tillage for reducing or eliminating disturbance to nests in small grain and rowcrops. Authors also discussed consequences of conservation tillage for wildlife outside of the breeding season and rodent infestations.

Rodgers, R. D. 1999. Why haven't pheasant populations in western Kansas increased with CRP? *Wildlife Society Bulletin* 27:654-665.

Study of pheasant decline (65%) in western Kansas from 1966-75 to 1986-1995. CRP fields were preferred by pheasant broods, but pheasant use of CRP in winter was reduced compared to weedy wheat fields. Decline attributed to increased herbicide treatment of wheat fields, inadequate plant diversity, poor stand maintenance, and large size of CRP fields. Authors recommended (1) interseeding of perennial legumes and other forbs into recently burned CRP fields and (2) strip-disking fireguards around CRP fields to facilitate burning, stimulate growth of broad-leaved annuals, and increase edge. It was anticipated that interspersed grass-legume strips on intensively farmed croplands through continuous CRP will improve pheasant habitat.

Roseberry, J. L., and L. M. David. 1992. The Conservation Reserve Program and northern bobwhite population trends in Illinois. Illinois Department of Conservation, Federal Aid in Wildlife Restoration Job Completion Report. Project W-106-R. 64 pp.

Roseberry, J. L., and L. M. David. 1994. The Conservation Reserve Program and northern bobwhite population trends in Illinois. *Transactions of the Illinois State Academy of Science* 87:61-70.

Contributions of CRP to improvements in Illinois quail habitat were less than expected. CRP land positively contributed to local habitat quality, but in some situations, CRP may have neutral or negative effects. CRP land comprised a small proportion of total

habitat base. CRP contribution to quail habitat could be improved if there was less midsummer mowing, more weedy vegetation as a consequence of strip disking and burning, and less planting of cool-season grasses.

Ryan, M. R. 1986. Nongame management in grassland and agricultural ecosystems. Pages 117-136 in J. B. Hale, L. B. Best and R. L. Clawson, editors. *Management of nongame wildlife in the Midwest: A developing art*. 74th Midwest Fish and Wildlife Conference. Chelsea, Michigan.

Acquisition, reclamation, and proper management of grassland resources must become a priority if we are to conserve the genetic diversity of native prairie flora and fauna. Grasslands contain substantial habitat diversity primarily in the horizontal plane. Author described grassland ecosystem as a mosaic of habitat types historically influenced by soil moisture and grazing intensity. Opportunities to manage prairie tracts of sufficient size to include all aspects of the prairie vegetation continuum are rare. They suggested that an alternative approach would be to manage smaller tracts as components of the overall prairie mosaic. Goal of nongame grassland management should be the conservation of wildlife species native to prairie habitats. Management actions must be defined on a state- or region-wide basis. If diversity of species indigenous to prairie ecosystems is objective, then the management plan must be developed on large scale and implemented through integrated management of local units.

Large blocks will contain more species than a small unit of similar habitats. However, there is controversy around the question of whether a large tract will maintain more species than several small tracts that combined are of equal size to the larger tract. Authors proposed the following ranking criteria for land acquisitions: (1) sites that regardless of size contain rare species or habitats that could support them; (2) large tracts that contain a mosaic of habitat types; (3) clusters of small tracts that provide or can be managed for a variety of components of the prairie mosaic; (4) large homogeneous blocks of grassland; and (5) small, highly isolated units of grassland.

Ryan, M. R., L. W. Burger, and E. W. Kurzejeski. 1998. The impact of CRP on avian wildlife: A review. *Journal of Production Agriculture* 11:61-66.

A review of grassland bird diversity, abundance, and reproductive success in CRP during breeding season in central United States. Over 90 species were documented using CRP planting during breeding season; > 40 species were recorded as nesting. Bird abundance in CRP was 1.4- to 10.5-times greater than in crop fields. Nest abundance was 8.8- to 27-times higher in CRP fields than in crop fields. Overall, CRP produced about 14-times more songbirds than crop fields. Characteristics of nesting waterfowl were similar in CRP fields and covers managed specifically for waterfowl production. Pheasant numbers three- to five-times higher

after CRP plantings were established. Nest success of pheasants in CRP was greater than necessary for population growth. Although use of CRP by bobwhites was substantial, direct evidence of CRP contributing to quail population growth was lacking.

Overall, CRP provided high-quality breeding habitat for many grassland birds, including several that have experienced long-term declines in populations. Avian response to CRP is sufficient to justify efforts to maintain long-term set-aside provisions in future federal legislation.

Ryan, M. R., L. W. Burger, Jr., E. W. Kurzejeski, and T. D. McCoy. 1995. The relationships of forage quality and land capability class with vegetation on CRP lands in northern Missouri. Final Report to the Missouri Department of Natural Resources. Jefferson City. 47 pp.

Sample, D. W., and M. J. Mossman. 1990. Conclusions from the Wisconsin Department of Natural Resources study of grassland bird use of CRP and ACR (set-aside) fields. Wisconsin Department of Natural Resources, Bureau of Research. Madison. 2 pp.

Sample, D. W., and M. J. Mossman. 1993. Habitat management guidelines for grassland birds on public and private land in Wisconsin. State of Wisconsin Memorandum, Bureau of Research. Madison. 13 pp.

Major causes of decline of grassland birds likely are loss of breeding habitat associated with conversion of pasture to rowcrops, and early and frequent mowing of alfalfa. Primary goal of habitat management for grassland birds should be to maximize the diversity and viability of grassland bird populations statewide and within region. Special attention should be given to identifying large tracts suitable for management.

Samson, F., and F. Knopf. 1994. Prairie conservation in North America. *Bioscience* 44:418-421.

Estimates of losses of native prairie since European settlement range up to 99.9% in some states. In addition to direct losses of habitat, overgrazing and recreational uses add to the stress on remnant prairies. Fifty-five grassland species currently are threatened. Authors advocated inventory and monitoring of remaining prairie ecosystems, management to discourage establishment of woody plants and woody corridors within prairie-dominated ecoregions, and realignment of administrative boundaries along ecoregion borders to increase efficiency in inventory and monitoring.

Sargeant, A. B. 1982. A case history of a dynamic resource - the red fox. Pages 121-137 in G. C.

Sanderson, editor. *Midwest furbearer management*. The Wildlife Society. North Central Section, Central Mountains and Plain Sections, and Kansas Chapter.

Red fox is a major predator of upland nesting birds. Westward expansion of agriculture created landscapes with high diversity and edge resulting in a more broad-based and stable food supply for foxes. Red fox generally increased in abundance in response to decline in coyote numbers.

Sauer, J. R., G. W. Pendleton, and B. G. Peterjohn. 1995. Evaluating causes of population changes in North American insectivorous songbirds. *Conservation Biology* 10:465-478.

Analysis of Breeding Bird Survey (BBS) data did not support the hypothesis that predation on breeding grounds played a causal role in population changes. Rather, results indicated that more species of Neotropical migrant birds have increased than have declined since the BBS began. Authors concluded that general declines have been recent and limited to the eastern part of continent.

Saunders, D. A. 1994. Can we integrate nature conservation with agricultural production? *Landscape and Urban Planning* 28:63-71.

Schenck, E. W., and L. L. Williamson. 1991. Conservation Reserve Program effects on wildlife and recreation. Pages 37-42 in L. A. Joyce, J. E. Mitchell, M. D. Skold, editors. *The Conservation Reserve - yesterday, today and tomorrow*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-203. 64 pp.

Paper summarized conservation practices by state for Midwest region. Acres of additional prime nesting habitat provided by CRP were calculated nationwide for pheasant, meadowlark, and bobwhite quail. Authors discussed economic benefits resulting from improved recreational opportunities provided by CRP.

Schmitz, R. A., and W. R. Clark. 1999. Survival of ring-necked pheasant hens during spring in relation to landscape features. *Journal of Wildlife Management* 63:147-154.

Spring survival and habitat use of hen pheasants compared between Iowa study sites having high habitat diversity with 25% grassland and low habitat diversity with 9.3% grassland. There were no differences between study sites in spring survival rate (76-81%) or home range size (37-48 ha). Risk of mortality increased with amount of edge in individual's home range. Predation by mammals, especially red fox, was major cause of mortality.

Schmidt, R. J., C. L. Mullins, M. Woody, and J. Knight. 1990. New Mexico's CRP and wildlife habitat improvement. *Transactions of the North American Wildlife and Natural Resources Conference* 55:68-73.

General description of CRP in New Mexico, including accomplishments, other conservation, and future prospects.

Schmutz, J. K. 1987. The effect of agriculture on ferruginous and Swainson's hawks. *Journal of Range Management* 40:438-440.

Raptors are an important component of plains ecosystems. Paper summarized the effects of cultivation and agricultural activity on hawk density in prairie region of Alberta. Density of ferruginous hawks declined with increasing cultivation. In contrast, Swainson's hawk density was higher in areas of moderate cultivation (11-30%) than in grassland (< 10% cultivation). Swainson's hawk tolerated high levels of cultivation (< 90%); ferruginous did not. Ferruginous hawks have great affinity for land with sparse and short vegetation and avoid areas where grasses are replaced by dense and tall crops. In contrast, Swainson's hawks are more highly adapted to smaller prey common in ungrazed grassy borders of ponds, roads, and farmsteads than in intensively grazed pastures. If small patches of natural or semi-natural cover containing trees or shrubs are strategically distributed in agricultural areas, Swainson's hawks are likely to remain in reasonable numbers. Ferruginous hawks require grassland and will be common only where this land use is dominant.

Schramm, H. L. Jr., L. M. Smith, F. C. Bryant, R. R. George, B. C. Thompson, S. A. Nelle, G. L. Valentine. 1987. Managing for wildlife with the Conservation Reserve Program. Texas Technical University, Management Note 11. 6 pp.

Schwartz, C., P. Jaynes, and P. Peditto. 1995. Northeast states wildlife needs assessment for 1995 Farm Bill. *Transactions of the North American Wildlife and Natural Resources Conference* 60:300-306.

Authors provided general review of the land use changes, and description of existing wildlife habitats in agricultural settings and status and trends of wildlife associated with wetlands, grasslands, and early-successional habitat, and rare, threatened, and endangered species. Goals presented for grassland, wetland, forest, and riparian habitats.

Shoemaker, R. 1989. The Conservation Reserve program and its effect on land values. U.S. Department of Agriculture, Economic Research Service, Agriculture Information Bulletin No. 554. 5 pp.

Bulletin concluded that producers enrolled in the CRP in 1986 and 1987 may have earned seven percent more with CRP than without it. Land values in the United States dropped eight percent between 1986 and 1987. The CRP helped cushion the decline in all land values by an estimated 0.3%.

Snyder, W. D. 1985. Survival of radio-marked hen ring-necked pheasants in Colorado. *Journal of Wildlife Management* 49:1044-1050.

Study estimated survival of radio-marked hen ring-necked pheasants in Colorado. Lowest monthly survival occurred in April due to predation by great horned owls, Cooper's hawks, and prairie falcons. Coyote and feral house cats were the primary mammalian predators. Characteristics of early spring residual cover influenced hen survival. Study area contained extensive tree and shrub plantings that attracted wintering pheasants and avian predators. Pheasants associated with trees incurred a higher rate of avian predation than counterparts in habitats not containing trees.

Soil and Water Conservation Society. 1994. When Conservation Reserve Program contracts expire: The policy options. Soil and Water Conservation Society. Ankeny, Iowa. 143 pp.

Proceedings of conference held in Arlington, Virginia, 10-11 February, 1994. Invited speakers addressed the program's history, and economic, social, and biological aspects of CRP.

Southern, E. C. 1984. Farm wildlife production: What does it cost? Transactions of the North American Wildlife and Natural Resources Conference 49:159-163.

Issues that negatively influence farmers' willingness to produce wildlife included (1) harassment and problems associated with increased hunting pressure and demand; (2) increased crop damage; and (3) loss of income from diverted lands. Effects of delayed haying were lower quantity and quality of hay forage. For example, dairy cows fed late-cut hay would require 1.5- to 2-times more grain supplement; the grain mixture needing to contain an additional 5% protein.

Can it be expected that farmers will carry the cost of providing wildlife habitat? The answer is reflected in the continued removal of wetlands, idle areas, and fencerows. If the costs of wildlife are compared to the costs of agricultural products (grain, hogs) the costs of production on prime farmland are very high. Raising pen-reared birds is a comparative bargain at these prices. Compensation to the farmer for wildlife habitat would probably need to be at least equal to 75-80% of the market value of the yield per acre of crop normally produced on set-aside land. Meaningful increase in wildlife numbers probably will require that at least 5% of land be devoted to wildlife habitat.

Any solution to production of wildlife on farmland must include the acceptance of farming practices that produce wildlife as a no-cost, byproduct of production. Agencies need to aggressively advocate and demonstrate farming technologies that help both the farmer and wildlife. The best approach for farmland wildlife management is to deal with resources and programs that encourage sound land use for all resources over the long-term. Wildlife's only hope on prime farmland is farm practices, programs, and policies that bring reduced costs or added income to the individual farmer.

Sovada, M. A., M. C. Zicus, R. J. Greenwood, D. P. Rave, W. E. Newton, R. O. Woodward, and J. A. Beiser. 2000. Relationships of habitat patch size to predator community and survival of duck nests. Journal of Wildlife Management 64:820-831.

Duck nest success and predator community composition examined in relation to size of discrete CRP fields in Prairie Pothole Region of United States, 1993-1995. The effect of patch size on nest success was influenced by date in nest initiation and year, but within-year comparisons for early and late nests suggested that nest success generally increased with size of CRP plot. Habitat features associated with activity indicators varied among predator species. Although authors were unable to identify CRP characteristics necessary to ensure duck nest success above threshold levels, they strongly recommend against creation of small isolated tracts without predator controls.

Stauffer, D. F., G. A. Cline, and M. J. Tonkovich. 1990. Evaluating potential effects of CRP on bobwhite quail in Piedmont, Virginia. Transactions of the North American Wildlife and Natural Resources Conference 55:75-76.

Conversion of cropland to permanent introduced herbaceous cover is likely to have a positive effect on the quality of quail habitat, but beneficial effects are likely to endure only so long as a suitable grass-forb mixture is maintained. If grasses such as tall fescue become dominant and form dense sod, then beneficial effects will be reduced.

As croplands are converted to pine plantations, the quality of converted areas for quail will decline. For the first five to seven years after conversion, plantations typically will furnish suitable herbaceous cover; however, the ability of the habitat to provide minimal understory cover needed by quail for nesting and brood-rearing will diminish as pines mature and the canopy begins to close. Generally, where conversion of cropland to CRP increases the overall habitat diversity and adds habitat components previously lacking, increases in quail populations can be expected. But when overall diversity in the landscape is reduced, quail populations are likely to decline. Authors concluded that the large amount of CRP being placed in pine plantations was likely to cause local declines in quail. They suggested that consideration needed to be given to the juxtaposition and interspersing of CRP; more diversity in habitat will be created by converting many smaller fields rather than by converting fewer large fields.

Swanson, D. A., D. P. Scott, and D. L. Risley. 1999. Wildlife benefits of the Conservation Reserve Program in Ohio. Journal of Soil and Water Conservation 54:390-394.

Use of CRP by grassland-dependent species was related to availability of CRP. More than half of fields sampled were mowed during the nesting season. Twenty-one of 40 fields were disturbed prior to August. On average, disturbed fields had 51% of acreage mowed or burned. Disturbed fields had significantly lower values for Visual Obstruction Reading, percent grass canopy cover, and mean herbaceous height. Mean age of fields was five years (two to seven years). Mean field size was 20 acres (8.1 ha). Contract species dominated with 82.5% in timothy, orchardgrass, and clover. Forty-three breeding bird species used CRP fields. Use by eastern meadowlarks and bobolinks was significantly greater in unused fields. All species were numerically more abundant in CRP fields that were contiguous with other grassland habitat.

Swanson, T. M. 1992. Wildlife and wildlands, diversity and development. Pages 1-14 in T. M. Swanson and E. B. Barbier, editors. *Economics for the wilds*. Island Press, Washington, D.C.

Diversity and development need not be mutually exclusive; in fact, maintaining the diversity of wild resources is a necessary condition for sustainable development. Wild resources should be treated as an input to the development process and cannot be excluded. The conservation of biodiversity implies the need to conserve not only a given stock of wildlife, but the capacity for the species to mix and evolve in an ongoing interactive process. In other words, the habitat must be provided that will meet the needs of the targeted species across the landscape as well as through time. Important to integrate the value of wildlife/biodiversity into the economic process rather than shield them from it. The economic value of resources will be the key to their continuing survival.

Swengel, S. R., and A. B. Swengel. 1999. Correlations in abundance of grassland songbirds and prairie butterflies. *Biological Conservation* 90:1-11.

Study in 109 midwestern prairie grasslands suggests that conservation programs benefiting grassland birds can be favorable for prairie specialist butterflies and that certain bird and butterfly species can be effective indicators for one another. Implication is that distantly related animal taxa can, in some cases, be useful indicators for habitat quality for each other.

Szentandrasi, S., S. Polasky, R. Berrens, and J. Leonard. 1995. Conserving biological diversity and the Conservation Reserve Program. *Growth and Change* 26:383-404.

Effective protection of wildlife species will often take place on land used primarily for purposes other than wildlife habitat. CRP lands currently are targeted to regions (e.g., Midwest and Great Plains) that have relatively few threatened and endangered species. Paper describes method to retarget CRP to address T&E species concerns in Oregon or other regions where there are greater numbers of these species. Authors argued that there is need for improved targeting of CRP if it is to continue to provide important environmental benefits. Primary agencies involved in management and monitoring of the CRP (USDA) do not have a traditional wildlife-oriented mission; consequently, species preservation and habitat protection considerations have been inadequately considered.

Taylor, M. W., C. W. Wolfe, and W. L. Baxter. 1978. Land use change and ring-necked pheasants in Nebraska. *Wildlife Society Bulletin* 6:226-230.

Study of the effects of land use changes on ring-necked pheasants in Nebraska. Positive relationships were detected between spring densities of hens and length of fencerows, acreage of pasture and hay, and area of wheat and wheat stubble. Populations were

inversely related to area of rowcrops, percent of land that was fall-tilled, and acreage of irrigated land. Irrigation generally involved extensive land leveling or clearing which eliminated idle areas, fencerows, old farmsteads, wetlands, and other habitats of high wildlife value. Tillage of crop residue in fall, especially wheat stubble, reduced cover for wildlife. Interspersion index was useful for predicting pheasant habitat quality and density of birds.

Thogmartin, W. E. 1999. Landscape attributes and nest site selection in wild turkeys. *Auk* 116:912-923.

Evaluation of landscape habitat characteristics that were important for placement and survival of wild turkey nests in the Ouachita Mountains, Arkansas. Hens selected short-leaved pine (68%) over mixed hardwoods (24%) and other habitats (8%). Fifty-eight percent of hens nested in edge habitat, but placement in such areas did not influence nest success. Hens nested in large patches away from areas of high edge density favored by predators. Nests located close to roads were uniformly unsuccessful. Habitat characteristics were good predictors of nest location but poor predictors of success. Author concluded that high abundance of edge in the landscape sustained predator populations and contributed to reduced nest success in large patches.

Thomas, M. B., S. D. Wratten, and N. W. Sotherton. 1991. Creation of island habitats in farmland to manipulate populations of beneficial arthropods: Predator densities and emigration. *Journal of Applied Ecology* 28:906-917.

Replacement of natural vegetation by crop monocultures can eliminate many indigenous insects. Diversification of habitat structure on both macro and micro scales will enhance abundance and diversity of insect populations. Decreased diversity of habitats associated with field enlargement resulted in lower density of insects in interiors of larger fields.

Thompson, F. R., S. J. Lewis, J. Green, and D. Ewert. 1993. Status of Neotropical migrant landbirds in the Midwest: Identifying species of management concern. Pages 145-158 in D. M. Finch and P. W. Stangel, editors. *Status and Management of Neotropical migratory birds*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-229. 422 pp.

Authors outlined ecosystem management approach that addressed the needs of the many species of high management concern in the Midwest. Grasslands were identified as one of several habitats that deserved special management attention. Grassland species of special management concern were (in order of decreasing importance): Baird's sparrow, dickcissel, mountain plover, bobolink, long-billed curlew, grasshopper sparrow, lark bunting, upland sandpiper, burrowing owl, scissor-tailed flycatcher, Swainson's hawk, lark sparrow.

Trautman, C. G. 1982. History, ecology and management of the ring-necked pheasant in South Dakota. South Dakota Department of Game and Parks. 118 pp.

Winter concentrations of pheasants were often located near weed patches, grain stubble, cornfields, and other food sources. Distances traveled rarely exceeded  $\frac{1}{4}$  mi. Proximity to available food was the dominant factor in choice of winter roosting sites. Marshlands provide high quality winter cover. Author provided a detailed description of ring-necked pheasant history, ecology, and management in South Dakota.

Trenbath, B. R., G. R. Conway, and I. A. Craig. 1990. Threats to sustainability in intensified agricultural systems: Analysis and implications for management. Pages 337-365 in S. R. Gliessman, editor. *Agroecology: Researching the ecological basis for sustainable agriculture*. Springer-Verlag, New York.

Agricultural intensification usually results in (1) a greater proportion of available land more intensively farmed; (2) an elevated level of technological input; and (3) more frequent use of a given area. The combination of these effects is often accompanied by damage to the natural resource base. May damage nonagricultural systems inside and outside of the developed area as well as other agricultural systems downstream of the area. Intensive exploitation of available area has led to increases in productivity but commonly leads to decline in wildlife populations. Where wildlife viability is dependent upon relatively large patches of less disturbed habitat, populations may disappear.

The more frequent use of land is a common aspect of intensification that is potentially exhaustive of land capability. With shorter fallow period between crops, natural soil processes may be unable to regenerate fertility and there may be a build up of pests—both of which require greater use of agrochemicals to alleviate problem. Use of pesticides may initially lead to spectacular increase in yields, but experience suggests that after a number of years of application, pesticides progressively lose their effectiveness. Decline in effectiveness is due to an increased proportion of pest genotypes in population that are resistant to chemicals. If use continues, especially at higher dosages, the proportion of resistant genotypes increases rapidly to point where the pesticide must be replaced by new chemical. Emergence of pesticide resistance reduces profitability because of crop losses and need for different, often more expensive, chemical.

Unevehr, L. J. 1993. Suburban consumers and exurban farmers: The changing political economy of food policy. *American Journal of Agricultural Economics* 75:1140-1144.

Larger trends in society frequently have implications for food and agricultural policy. Three current trends were indicated: declining importance of farms, suburbanization, and skewed distribution of income growth. Resident farm population represented < 2% of the

U.S. population; farm labor accounted for < 3% of labor force. Farm population declined by 24% during the 80s. Other trends: fewer Americans have direct ties to agriculture; farming is a smaller part of the rural economy; farm resident population accounts for only 7% of rural population; farm production and prices continue to become less important to consumers; fewer farm ties means less sympathy with farmers' objectives or with agrarianism in general; reduced support for traditional farm commodity program goals. By 21st century, if not before, it was projected that suburban areas will account for more than half of U.S. population. Important political battles will focus increasingly on the important suburban vote. Suburban voters have become increasingly concerned about preserving open space and the impacts of agriculture on environmental quality and personal health. They have high expectations for public goods and possess the means to pursue desires through the political process. Pressure groups will have greater influence on policies, including agricultural legislation. There will continue to be demands for greater accountability in government spending, a trend which will affect all government programs.

U.S. Congress, Office of Technology Assessment. 1995. Targeting environmental priorities in agriculture: Reforming program strategies. OTA-ENV-640. 72 pp.

Damages associated with agricultural activity vary widely depending on how production practices affect an area's natural resources. Federal programs must be targeted to priority areas and successfully apply low-cost approaches to achieve the greatest returns for tax expenditures. Agroenvironmental priority areas were identified on a national scale for wildlife habitat; surface water, groundwater, and soil quality; rangeland; water conservation; rural landscapes; and wetlands and riparian areas. Legislation should use targeting procedure to maximize environmental benefits. Development and adoption of technologies that sustain privately profitable production and achieve environmental objectives must be linked with agroenvironmental programs.

U.S. Congress, Office of Technology Assessment. 1995. Agriculture, trade, and environment: Achieving complementary policies. OTA-ENV-617. 241 pp.

Current agricultural and environmental policies do not promote interests of U.S. farmers, traders, consumers, or taxpayers efficiently. Many policies are in conflict and may impede the nation's environmental priorities. Document described connections among agriculture, trade, environment, and related government policies and programs. Report concluded that many agricultural programs were obsolete and were not accurately targeted. Research on environmental issues related to agriculture was dramatically underfunded. Government needed to define and adopt policies that expanded U.S. agricultural exports and upgraded environmental quality associated with agricultural land use and production.

U.S. Department Agriculture. 1993. Conservation Reserve Program: Cost-effectiveness is uncertain. U.S. General Accounting Office, GAO/RCED-93-132. 14 pp.

Precise balance between the costs and environmental benefits of CRP cannot be calculated because dollar value of the environmental benefits from the program cannot be accurately assessed. The USDA has not quantified the effect on the environment of removing enrolled acres from production. USDA will pay more than \$91 billion to remove 63.5 million acres from production over 10-year life of the program. Benefits perceived to be only temporary. USDA goals for the program were to reduce commodity production, support farm income, and to provide environmental benefits. As a result of these other goals, projects with fewer environmental benefits were initially allowed into the program. Other USDA programs (Conservation Compliance, Agricultural Conservation Program, and Small Watershed Program) were identified as covering more acres of cropland, costing less, and providing more long-term environmental benefits. However, these programs were not intended to curb excess production and only indirectly supported farm incomes. Advantages of these programs were that they do not take land out of production.

U.S. General Accounting Office. 1989. Farm Programs: Conservation Reserve Program could be less costly and more effective. Report to the Chairman, Committee on Agriculture, Nutrition, and Forestry, U.S. Senate. GAO/RCED-90-13. Washington, D.C. 79 pp.

USDA could improve effectiveness of CRP by targeting cropland eroding at the highest rates and land that contributed most to surface water and groundwater contamination. CRP cost will be offset to some extent as farmers enroll acres that would otherwise be used for growing crops covered by price and income support programs. USDA incurred additional cost in tree planting initiative in five southeastern states. Higher rental rates were paid to all farmers regardless of whether they planted trees. USDA instructions to local county offices allowed CRP rental rates in many areas to exceed local rental rates. Report recommended that USDA implement competitive bid system and modify the 25% limit on acreage to allow more flexibility in program enrollment.

U.S. General Accounting Office. 1995. Conservation Reserve Program: Alternatives are available for managing environmentally sensitive cropland. GAO/RCED-95-42. Washington, D.C. 68 pp.

Vance, D. R. 1976. Changes in land use and wildlife populations in southeastern Illinois. *Wildlife Society Bulletin* 4:11-15.

Paper summarized consequences of land use changes on wildlife populations in southeastern Illinois from 1939 to 1974. Extensive grasslands and fencerows were reduced by 48%. Intense cash-grain

farming was expected to cause further declines in habitat and populations. Soybeans had largely replaced grassland. Remaining grassland (1% of area) was overgrazed pasture. Three major components of habitat, grassland, woody cover, and edge, were reduced by intensification of agricultural production. What remains of edge was of little value because of lower structural diversity. Author stated that 14 species of birds had declined due to loss of grassland, edge, and savanna type habitats in southeastern Illinois.

Voigt, D. R. 1987. Red fox. Pages 378-392 in M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, editors. *Wild furbearer management in North America*. Ontario Ministry of Natural Resources, Toronto, Canada.

Increases in red fox numbers were associated with declines in coyote. Competition with other canids, particularly coyote, strongly influenced numbers of fox but not their distribution. Foxes avoided raising pups in areas where coyotes had established a home range.

Voigt, D. R., and B. D. Earle. 1983. Avoidance of coyotes by red fox families. *Journal of Wildlife Management* 47:852-857.

Foxes avoided raising pups in areas where coyotes traveled and raised pups. Coyote ranges were five- to seven-times larger than fox territories and may significantly limit the number of fox families in an area.

Wachob, D. G. 1997. The effects of the Conservation Reserve Program on wildlife in southeastern Wyoming. Ph.D. dissertation. University of Wyoming, Laramie.

Study conducted in southeastern Wyoming in 1993-1994 related vegetative and spatial characteristics of CRP to habitat use by nongame birds, small rodents, sharp-tailed grouse, raptors, carnivores, and big game. Annual differences in nongame bird responses to vegetative structure and occurrence of alfalfa, but nongame bird use was unrelated to spatial characteristics of CRP. Small mammal use was affected by vegetative (species richness, height, and SD of cover) and spatial characteristics (area). CRP was used by sharp-tailed grouse for nesting and brood-rearing and associated with size and number of leks. Simulations of hypothetical landscape for 28 common species suggested species richness increased rapidly as CRP coverage increased from 0 to 15% and less rapidly between 15 and 50%.

Warner, R. E. 1992. Nest ecology of grassland passerines on road rights-of-way in central Illinois. *Biological Conservation* 59:1-7.

Availability of suitable grassland cover has decreased in response to increased in rowcrop farming. Fescue stands sustained relatively few breeding birds. Where farming was diversified and habitat conditions were favorable, rights-of-way and other linear habitats received high use by birds. Use was influenced by habitat condi-

tions in vicinity of the strip and regional land uses. Managed roadsides were important to passerines even where hayland was present because most nests in haylands were destroyed during cutting. Management recommendations were (1) seed areas to brome-alfalfa and or native grasses and forbs; (2) delay mowing until after August 1; (3) maximize strip width; (4) shelterbelts and woody plants should be established in some areas to enhance diversity of species.

Warner, R. E. 1994. Agricultural land use and grassland habitat in Illinois: Future shock for midwestern birds. *Conservation Biology* 8:147-156.

During the period of most intensive agricultural production, grasslands existed only as linear edges with resultant low density and diversity of grassland nesting birds. Nest densities and species diversity were highest where grassland was nearby, cover types were heterogeneous, and where corridors connected grasslands in surrounding landscape. Nest destruction was high in years when both predators and nesting pheasants were concentrated in relatively little grassy cover. The percentage of pheasant nests hatched annually from 1973 to 1981 was positively correlated with the amount of grassland per hen in spring, where grassland was defined as both edge habitats (including roadsides) and fields of hay and small grain. Landscape characteristics were associated with use of edges by nesting birds and reproductive success. Nest densities and species diversity increased with spatial heterogeneity and connectivity in the landscape. Use of grassy farmland edges would be enhanced by establishing herbaceous buffer strips along field borders and existing edges, and by locating hay and small grains near grassland corridors. Not all linear habitats are predator traps. Predation rates vary with predatory-prey assemblages, density of birds in nest habitats, and extent to which other cover and prey attract predators away from relatively attractive nest sites. Landscape-level phenomena poorly understood at this time.

Warner, R. E., L. M. David, S. L. Etter, and G. B. Joselyn. 1992. Costs and benefits of roadside management for ring-necked pheasants in Illinois. *Wildlife Society Bulletin* 20:279-285.

Mitigating the effects of agricultural land use on upland wildlife remains a challenge to resource agencies. Successful habitat programs in agricultural environment are those that are compatible with farming operations. Habitat initiatives are rarely evaluated relative to their effect on target species, economics, or the perceptions of cooperating landholders. Roadside rights-of-way are frequently mowed during the growing season and, consequently, have little habitat value for nesting pheasants. Paper summarized economic costs and benefits of roadside seeding and maintenance in relation to improved habitat availability and production of pheasants.

Warner, R. E., and S. L. Etter. 1985. Farm conservation measures to benefit wildlife, especially pheasant populations. *Transactions of the North American Wildlife and Natural Resources Conference* 50:135-141.

Authors suggested that three spatial factors were key to understanding the interaction of agriculture and pheasants: (1) field, primary site for particular biological needs; (2) farm, represents a unit of land management and describes cover types near sites of biological activity; (3) region, mosaic of cover over an extended area that encompasses several farms. All scales influence the occurrence, location, and outcome of specific events in the life of pheasants. Scales vary in importance from season to season depending upon weather, type of farming, and biological activity. Regional scale is important to movements during crop harvest, fall tillage, winter grouping, and spring dispersal. Farm scale is important during brood-rearing and establishment of territories. Field scale most relevant to nest success, roosting, and predation.

Ideally, management practices should extend over several contiguous townships. Habitat should be adequate to permit movements of birds from farm-to-farm in response to individual farm management activities. Conservation measures must be extensive and long-term to significantly benefit pheasant populations. Addressing factors that are critical during the reproductive season are first priority.

Warner, R. E., and S. L. Etter. 1986. The dynamics of agriculture and ring-necked pheasant populations in the Cornbelt, U.S.A. *World Pheasant Association Journal* 11:76-89.

Warner, R. E., S. L. Etter, L. M. David, and P. C. Mankin. 2000. Annual set-aside programs: A long-term perspective of habitat quality in Illinois and the Midwest. *Wildlife Society Bulletin* 28:347-354.

Description of land use changes in Illinois and trend toward short-term set-aside programs between 1962-63 and 1991-94. Annual set-asides were inadequate to preserve diversity and abundance of prairie-nesting birds. Study documented diminution in measured habitat attributes (heterogeneity of vegetation, disturbance during growing season, persistence of vegetation between years, connectivity of grassy fields) between 1962-63 and 1991-94. Authors recommended multi-year set-asides with grassland preserves and development of sustainable farming systems that accommodate wildlife.

Washburn, B. E., T. G. Barnes, and J. D. Sole. 2000. Improving northern bobwhite habitat by converting tall fescue fields to native warm-season grasses. *Wildlife Society Bulletin* 28:97-104.

Evaluation of the efficacy of techniques to kill tall fescue and establish native warm-season grasses to improve habitat for northern bobwhite quail in Kentucky. Best treatment to kill tall fescue and establish native warm-season grasses was a spring burn followed by a preemergence imazapic application and seeding of native warm-season grasses.

Weitman, D. 1994. Water quality improvement and wetlands restoration. Pages 20-22 in *When Conservation Reserve Program contracts expire: The policy options*. Soil and Water Conservation Society. Ankeny, Iowa.

Water quality benefits of CRP and wetland restoration were unknown. Nonetheless, author argued that because agriculture was the most significant cause of water quality problems, CRP must be tailored to focus on water quality priorities to contribute significantly to national clean water strategy. Two million acres of riparian areas may be most cost-effective way to protect water quality through CRP. Author recommended that program be restructured to promote long-term easements.

Westemeier, R. L. 1983. Responses and impact by pheasants on prairie chicken sanctuaries in Illinois: A synopsis. Pages 117-122 in R. T. Dunabe, R. B. Stiehl, and R. B. Kahl, editors. *Perdix III: Gray partridge and ring-necked pheasant workshop*. Wisconsin Department of Natural Resources, Madison.

Western, D. 1989. Conservation without parks: Wildlife in the rural landscape. Pages 158-165 in D. Western and M. C. Pearl, editors. *Conservation for the twenty-first century*. Oxford University Press, New York.

Whitmore, R. 1982. Insect biomass in agronomic crops as food for ring-necked pheasant chicks. Ph.D. dissertation. University of Nebraska, Lincoln. 64 pp.

Corn, soybeans, and alfalfa had significantly lower amounts of insect biomass than wheat, oats, sweetclover, and oats-sweetclover. Estimated number of chicks/ha supported by insect biomass in various crops was 8 in corn, 10 in soybeans, 64 in sweetclover, 86 in oats, and 106 in oats-sweetclover.

White, B. 1992. Managing CRP grasslands for bobwhite quail. U.S. Soil Conservation Service, Biology Technical Note MO-14. 5 pp.

Whiteside, R. W. 1983. Aspects of the ecology and management of pheasants in the high plains of Texas. Ph.D. dissertation. Texas Tech University, Lubbock. 65 pp.

Whitworth, M. R., and D. C. Martin. 1990. Instream benefits of CRP filter strips. *Transactions of the North American Wildlife and Natural Resources Conference* 55:40-45.

Study compared biological indices (macroinvertebrate abundance and diversity, fish, community-level biotic indices, and fish population-level indices) in Indiana and North Carolina streams with and without filter strips. Benthic macroinvertebrates and fish communities showed significant differences between buffered and nonbuffered stream segments. Authors concluded that vegetative filter strips can benefit small headwater streams in agricultural regions.

Wildlife Management Institute. 1994. *America needs the Conservation Reserve Program*. Washington, D.C. 16 pp.

Wildlife Management Institute. 1995. *How much is enough? A regional wildlife habitat needs assessment for the 1995 Farm Bill*. Washington, D.C. 30 pp.

Wildlife Society. 1995. *1995 Farm Bill: Wildlife options in agricultural policy*. Wildlife Society, Technical Review 95-1. 23 pp.

Williams, B. K., M. D. Koneff, and D. A. Smith. 1999. Evaluation of waterfowl conservation under the North American Waterfowl Management Plan. *Journal of Wildlife Management* 63:417-440.

Paper reviewed efforts to evaluate the North American Waterfowl Management Plan. Summary provided for results from selected assessments of intensive (e.g., planted cover, electrified fencing, wetland conservation, nesting structures, nesting islands, and predator removal) and extensive management treatments (e.g., rotational grazing, delayed haying, conservation tillage, constructed wetlands, upland cover, beaver pond management). Associations between habitats and reproduction, recruitment, and survival were discussed. Authors concluded that there was need for ongoing and

more carefully prioritized conservation efforts, broader partnerships, improved understanding of links between habitats and biological processes.

Williams, C. F., and J. W. Mjelde. 1994. Conducting a financial analysis of quail hunting within the Conservation Reserve Program. *Wildlife Society Bulletin* 22: 233-241.

Upsurge in outdoor recreation has strained the public land system. Public hunting lands remain in short supply. Authors concluded that the greatest opportunity to supply quality hunting was the development of opportunities on private land.

Willson, G. D. 1995. The Great Plains. Pages 295-296 in E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. *Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems*. U.S. Department of the Interior, National Biological Service, Washington, D.C.

Introduction to chapter reviewing effects of > 100 years of postsettlement manipulation of the Great Plains ecosystem on grassland birds, migratory birds in North Dakota, waterfowl nesting success, prairie fishes, and canids.

Wilson, S. D., and J. W. Belcher. 1989. Plant and bird communities of native prairie and introduced Eurasian vegetation in Manitoba, Canada. *Conservation Biology* 3:39-44.

Study examined effect of introduced plants on native plants and bird communities in a mosaic of North American mixed-grass prairie and Eurasian vegetation. All bird species were native to prairie. Bird abundance was the same in native and introduced vegetation, but two of eight species were more abundant in native than in introduced vegetation. None were more common in introduced vegetation. A correlation matrix calculated for all bird species and 10 most abundant plant species divided the bird community into two groups: western meadowlark, upland sandpiper, Sprague's pipit, Baird's sparrow, and savannah sparrow positively associated with native plants; vesper sparrow, clay-colored sparrow, and grasshopper sparrow negatively associated with native plants. Authors concluded that plant introductions had important effects on native plant and bird communities.

Winter, M. 1999. Nesting biology of dickcissels and Henslow's sparrows in southwestern Missouri prairie fragments. *Wilson Bulletin* 111:515-527.

A comparison of nesting biology of dickcissels and Henslow's sparrows to provide insight into factors potentially contributing to population declines in southwestern Missouri. Species nesting in tall grass prairie fragments had similar clutch sizes, rates of hatching success, and numbers of fledglings/nest, but dickcissels tended to have reduced nesting success and higher rates of brood parasitism than Henslow's sparrows. Vegetative characteristics differed between successful and depredated dickcissel nests, but no differences were detected between successful and depredated Henslow's sparrow nests or parasitized and unparasitized dickcissel nests.

Winter, M., D. H. Johnson, and J. Faaborg. 2000. Evidence for edge effects on multiple levels in tallgrass prairie. *Condor* 102:256-266.

Analysis of the effects of edge on predator distribution and survival of artificial nests and natural nests of dickcissels and Henslow's sparrows in native tallgrass prairie system in southwestern Missouri. Survival of artificial nests reduced along forest edge; dickcissel and Henslow's sparrow nest success was lower along shrub edge, but nest fates were unrelated to distance from roads, agricultural fields, or forests. Authors argued that edge effects were more pronounced than area effects and attributed edge effect to mid-sized carnivores. Further, species responded to edge by reducing density (Henslow's sparrows) or decreased nest success (dickcissel).

Wooley, J. R. George, B. Ohde, and W. Rybarczyk. 1982. Nesting evaluations of native grass pastures and narrow-row soybeans. Pages 5-6 in R. B. Dahlgren, compiler. *Proceedings of Midwest Agricultural Interfaces with Fish and Wildlife Resources Workshop*. Iowa State University, Iowa Cooperative Fish and Wildlife Research Unit, Ames.

Native grasses have a dense growth form similar to other types of pheasant nest cover and are unlikely to be mowed or grazed until after most eggs hatch. Leaving the recommended 20-25 cm (8-10 in) stubble to ensure optimum plant growth should provide residual cover for nesting the following spring.

Pheasant nest densities were high in both switchgrass and little bluestem, but nest success was greatest in switchgrass. Mowing operations in early June destroyed all nests and killed 8 of 11 hens nesting in alfalfa/orchard grass. Pheasant and passerine nest success was higher in switchgrass that was not grazed or mowed the previous summer. Residual cover in undisturbed switchgrass apparently was more attractive to nesting females than that in disturbed fields and resulted in greater numbers of successful nests. Switchgrass managed for nest cover should be left undisturbed.

Young, C. E., and C. T. Osborn. 1990. The Conservation Reserve Program: An economic assessment. U.S. Department of Agriculture, Economic Research Service, Agriculture Economic Report 626. 32 pp.

Young, L. S. 1989. Effects of agriculture on raptors in the western United States: An overview. Pages 209-218 in *Proceedings of the Western Raptor Management Symposium and Workshop*. National Wildlife Federation, Washington, D.C.

Young, R. E., G. M. Adams, and B. Willcott. 1994. Extending CRP contracts vs. commodity program costs. Pages 30-34 in *When Conservation Reserve Program contracts expire: The policy options*. Soil and Water Conservation Society, Ankeny, Iowa.

Analysis of the effects of CRP extensions on commodity support budget. Authors concluded extension of CRP would serve to tighten commodity supplies, thereby pushing commodity prices up and reducing deficiency payments.

Zinn, J. 1993. The next generation of U.S. agricultural conservation policy. Soil and Water Conservation Society, Ankeny, Iowa. 40 pp.

White paper based on results from National Soil and Water Conservation Society forum (March 14-16 1993) of stakeholders and interest groups to assess how current agricultural policies were working. Paper provided detailed summaries of current strong and weak points pertaining to effects of agricultural policies on environmental issues. Paper also presented results of regional focus group, summary of problems, and potential solutions to agriculturally related issues.

## Appendix III: Scientific and Common Names of Birds

### ODICIPEDIFORMES

#### PODICIPEDIDAE

*Podilymbus podiceps*, Pied-billed Grebe

### ANSERIFORMES

#### ANATIDAE

Anserinae

*Cygnus columbianus*, Tundra Swan

Anatinae

*Aix sponsa*, Wood Duck

*Anas strepera*, Gadwall

*Anas platyrhynchos*, Mallard

*Anas discors*, Blue-winged Teal

*Anas clypeata*, Northern Shoveler

*Anas acuta*, Northern Pintail

### FALCONIFORMES

#### ACCIPITRIDAE

Accipitrinae

*Circus cyaneus*, Northern Harrier

*Buteo jamaicensis*, Red-tailed Hawk

#### FALCONIDAE

Falconinae

*Falco sparverius*, American Kestrel

### GALLIFORMES

#### PHASIANIDAE

Phasianinae

*Perdix perdix*, Gray Partridge

*Phasianus colchicus*, Ring-necked Pheasant

Tetraoninae

*Tympanuchus phasianellus*, Sharp-tailed Grouse

*Tympanuchus cupido*, Greater Prairie-Chicken

Meleagridinae

*Meleagris gallopavo*, Wild Turkey

#### ODONTOPHORIDAE

*Colinus virginianus*, Northern Bobwhite

### GRUIFORMES

#### RALLIDAE

*Porzana carolina*, Sora

### CHARADRIIFORMES

#### CHARADRIIDAE

Charadriinae

*Charadrius vociferus*, Killdeer

#### RECURVIROSTRIDAE

*Himantopus mexicanus*, Black-necked Stilt

### SCOLOPACIDAE

*Tringa solitaria*, Solitary Sandpiper

*Actitis macularia*, Spotted Sandpiper

*Bartramia longicauda*, Upland Sandpiper

*Gallinago gallinago*, Common Snipe

Phalaropodinae

*Phalaropus tricolor*, Wilson's Phalarope

### LARIDAE

Sterninae

*Chlidonias niger*, Black Tern

### COLUMBIFORMES

#### COLUMBIDAE

*Columba livia*, Rock Dove

*Zenaida macroura*, Mourning Dove

### CUCULIFORMES

#### CUCULIDAE

Coccyzinae

*Coccyzus erythrophthalmus*, Black-billed Cuckoo

*Coccyzus americanus*, Yellow-billed Cuckoo

### STRIGIFORMES

#### STRIGIDAE

*Bubo virginianus*, Great Horned Owl

### APODIFORMES

#### APODIDAE

Chaeturinae

*Chaetura pelagica*, Chimney swift

### PICIFORMES

#### PICIDAE

Picinae

*Melanerpes erythrocephalus*, Red-headed Woodpecker

*Melanerpes carolinus*, Red-bellied Woodpecker

*Picoides pubescens*, Downy Woodpecker

*Colaptes auratus*, Northern Flicker

#### TYRANNIDAE

Fluvicolinae

*Empidonax virescens*, Acadian Flycatcher

*Empidonax minimus*, Least Flycatcher

Tyranninae

*Tyrannus verticalis*, Western Kingbird

*Tyrannus tyrannus*, Eastern Kingbird

#### LANIIDAE

*Lanius ludovicianus*, Loggerhead Shrike

#### VIREONIDAE

*Virco gilvus*, Warbling Vireo

*Vireo griseus*, White-eyed Vireo

*Vireo olivaceus*, Red-eyed Vireo

#### CORVIDAE

*Cyanocitta cristata*, Blue Jay

*Corvus brachyrhynchos*, American Crow

## ALAUDIDAE

*Eremophila alpestris*, Horned Lark

## HIRUNDINIDAE

Hirundininae

*Tachycineta bicolor*, Tree Swallow

*Petrochelidon pyrrhonota*, Cliff Swallow

*Hirundo rustica*, Barn Swallow

## PARIDAE

*Poecile carolinensis*, Carolina Chickadee

*Poecile atricapilla*, Black-capped Chickadee

## TROGLODYTIDAE

*Thryothorus ludovicianus*, Carolina Wren

*Cistothorus platensis*, Sedge Wren

*Cistothorus palustris*, Marsh Wren

## REGULIDAE

*Regulus satrapa*, Golden-crowned Kinglet

*Regulus calendula*, Ruby-crowned Kinglet

## SYLVIIDAE

Polioptilinae

*Polioptila caerulea*, Blue-gray Gnatcatcher

## TURDIDAE

*Sialia sialis*, Eastern Bluebird

*Hylocichla mustelina*, Wood Thrush

*Turdus migratorius*, American Robin

## MIMIDAE

*Mimus polyglottos*, Northern Mockingbird

*Dumetella carolinensis*, Gray Catbird

*Toxostoma rufum*, Brown Thrasher

## STURNIDAE

*Sturnus vulgaris*, European Starling (I)

## MOTACILLIDAE

*Anthus spragueii*, Sprague's Pipit

## PARULIDAE

*Dendroica pinus*, Pine Warbler

*Dendroica discolor*, Prairie Warbler

*Protonotaria citrea*, Prothonotary Warbler

*Geothlypis trichas*, Common Yellowthroat

*Wilsonia citrina*, Hooded Warbler

*Wilsonia pusilla*, Wilson's Warbler

*Icteria virens*, Yellow-breasted Chat

## EMBERIZIDAE

*Pipilo erythrophthalmus*, Eastern Towhee

*Aimophila cassinii*, Cassin's Sparrow

*Aimophila aestivalis*, Bachman's Sparrow

*Spizella arborea*, American Tree Sparrow

*Spizella passerina*, Chipping Sparrow

*Spizella pallida*, Clay-colored Sparrow

*Spizella breweri*, Brewer's Sparrow

*Spizella pusilla*, Field Sparrow

*Pooecetes gramineus*, Vesper Sparrow

*Chondestes grammacus*, Lark Sparrow

*Calamospiza melanocorys*, Lark Bunting

*Passerculus sandwichensis*, Savannah Sparrow

*Ammodramus savannarum*, Grasshopper Sparrow

*Ammodramus bairdii*, Baird's Sparrow

*Ammodramus henslowii*, Henslow's Sparrow

*Ammodramus leconteii*, Le Conte's Sparrow

*Melospiza melodia*, Song Sparrow

*Melospiza georgiana*, Swamp Sparrow

*Zonotrichia albicollis*, White-throated Sparrow

*Junco hyemalis*, Dark-eyed Junco

*Calcarius ornatus*, Chestnut-collared Longspur

## CARDINALIDAE

*Cardinalis cardinalis*, Northern Cardinal

*Phœucticus ludovicianus*, Rose-breasted Grosbeak

*Passerina cyanea*, Indigo Bunting

*Passerina ciris*, Painted Bunting

*Spiza americana*, Dickcissel

## ICTERIDAE

*Agelaius phoeniceus*, Red-winged Blackbird

*Dolichonyx oryzivorus*, Bobolink

*Sturnella magna*, Eastern Meadowlark

*Sturnella neglecta*, Western Meadowlark

*Xanthocephalus xanthocephalus*, Yellow-headed Blackbird

*Euphagus cyanocephalus*, Brewer's Blackbird

*Quiscalus quiscula*, Common Grackle

*Molothrus ater*, Brown-headed Cowbird

*Icterus spurius*, Orchard Oriole

*Icterus galbula*, Baltimore Oriole

## FRINGILLIDAE

Carduelinae

*Carduelis tristis*, American Goldfinch

## PASSERIDAE

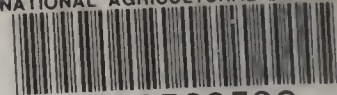
*Passer domesticus*, House Sparrow

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